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OPERATIONAL INFLUENCES ON MAINTAINABILITY

Westinghouse Defense & Electronic Systems Center

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ROME AIR DEVELOPMENT CENTER
Air Force Systems Command
Griffiss Air Force Base, New York 13441

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This report presents the results of a study of the operational influences on the field maintainability of USAF ground electronic equipment. The study identifies operational factors which contribute to the increase in field equipment mean time to repair (MTTR) from values estimated during equipment development. A checklist type model is included in the report which can be used to estimate the field MTTR given a maintainability prediction and knowledge of the influencing factors.

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Preface

This final report was prepared by the Westinghouse Electric Corporation's Defense and Electronic Systems Center, Baltimore, Maryland. The primary objective of the study was to examine and define the causes of the quantitative variation between prediction and field-observed maintainability on Air Force ground electronic systems. From these differences a basis was established for modifying current maintainability prediction techniques so as to account more adequately for the effects of the operational influences in field maintainability. The original program was scheduled to begin 1 May 1974 and terminate 30 April 1975; however, because of various delays in data procurement, the program was extended through 28 February 1977 at no additional cost to the government.

Mr. Eugene Fiorentino was the Rome Air Development Center's Project Engineer. Under his direction and with the cooperation of Mr. Frederick Helderbrack of the Air Defense System, Colorado Springs, Colorado, and Mr. Jack Hensley of the Sacramento Air Logistic Command, Sacramento, California, the necessary Air Force equipment data was gathered for the study.

The Westinghouse's Maintainability/Built-In-Test group under the management of Mr. James Victor was responsible for program execution. The Principal Investigator was Mr. Lawrence Phaller; Mr. David Koo was the Project Engineer. Mr. Gib Brandon (field data analysis), Ms Yvonne Lord (overall program and data coordination), Mr. William McDill (data analysis) and Messrs. Russell McMorris and Paul Smith (field site visits) all of Weatinghouse, provided additional support which contributed to the overall success of the program and content of this report.

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EVALUATION

1. The objectives of this study were to: (a) investigate and define the causes for the differences between the predicted and field observed maintainability of Air Force ground electronic equipment and (b) develop a method for estimating the field maintainability given the prediction analysis, the maintenance and support concepts, and knowledge of the reasons for the prediction-field differences.

2. The study objectives have been satisfactorily achieved. The investigation was based upon a detailed comparative analysis of maintainability prediction, domonstration, and field data for selected ground electronic equipments. Many factors were found to influence the field maintainability. Taken overall, these factors were found to result in increases in the field mean corrective maintenance time averaging approximately four times predicted values. A checklist model was developed which can be used to obtain field maintainability estimates using prediction and/or demonstration results. The model can also be used as a means for focusing attention on those operational influences which have the greatest overall impact on equipment downtime.

3. It is significant to note that, for the equipments studied, the operational influences outweigh any prediction-field differences which may come about solely from prediction technique inaccuracies. Adequate attention to the potential operational influences during the system design and support planning stages, therefore, may realize the greatest overall reductions in equipment downtime. In a broader sense, however, such attention is best applied in a life cycle cost/operational availability framework rather than being based solely in the maintainability domain.

Eugene Fiorentino

EUGENE FIORENTINO
Project Engineer

1. EXECUTIVE SUMMARY

The field observed values of the active repair time for ground electronic equipment have historically been much greater than specified and predicted values. Comparisons of field mean-time-to-repair for various ground electronic equipment (administrative and logistic delays excluded) have shown differences as large as 8:1. Such large differences clearly pose several questions:

- Do the predicted techniques adequately account for the most significant design and operational factors and their effects on equipment repair time?
- How much of the difference is attributable to operational differences?
- How much of the difference is traceable to "hidden" delay"

The purpose of this study is to examine and define the causes of this variation between predicted and field-observed maintainability on Air Force ground electronic systems, and establish a basis for modifying current maintainability prediction techniques so as to more adequately account for the effects of the operational influences in field maintainability.

The approach used in this study for identifying these factors and developing the mathematical model consisted of a 5 step program:

- Identify a set of components to be studied which represent various design and support concepts.
- Select a cross section of field sites for Westinghouse on-site investigations.
- Collect existing predictions, contractor collected, field, formal demonstration and Air Force (66-1) (65-110) data.
- Analyze all data for differences and identify operational influences effecting these differences.
- Construct a heuristic mathematical model which correlates the identified factors with the collected data.

Of fourteen candidate systems, four equipments were selected for study and seven Air Force field deployment sites using these systems were visited by Westinghouse for field interviews and data collection. The information, gathered along with the Air Force 66-1/65-110 data reflecting corrective maintenance over the period from 1 July 1973 through 30 June 1974, was correlated and the factors, both manufacturer and operational, affecting maintainability were identified. The more significant factors are summarized here.

SUMMARY OF INFLUENCES AFFECTING FIELD MAINTAINABILITY

Factor	Relative Influence
I. Manufacturer's Inherent Inaccuracy of Initial Analysis	
A. Inaccurate Repair Weight Weighting (variance in failure rate).	Very small
B. Prediction Techniques do not include all possible equipment/component failure modes that can occur (based on catastrophic failures only).	Medium
C. Time Lag between M_{ct} prediction and the hardware deployment.	Small
D. Analyst Optimism in assessing maintainability factors (accessibility, test failures, training, and other support functions).	Small
E. MIL-STD-472 Prediction Technique Inadequacies.	Small
II. Operational	
A. Maintenance Concept Mismatch (between field practiced and analyst assumed)	
1. Personnel	
• Skill level does not comply with planned.	Very small
• Blend of career oriented versus non-carrer oriented technicians vary.	Very small
2. Spares	
• Sparing levels, (amounts and level of replacement) as delineated in planned maintenance concept not available	Medium
• Replacement Spares not operational.	Very small
3. Technical Documentation	
• Documentation unavailable.	Very small
• Documentation up-to-dateness/completeness not finished.	Very small

4. Support/Test Equipment and Accessories

- Special test equipment as recommended not available. — Medium
- Special handtools recommended in technical documentation not available. — Large

5. Training (as it effects proficiency).

- Formal training as recommended by contractor not conducted. — Very small
- Supervised on-site "on-equipment" training does not comply with planned concept. — Medium

6. System Design Mechanization

- Field level repair is performed to lower level than planned, thus making designed-in built-in test equipment inadequate. — Medium

B. Base Physical Environment (including facilities)

1. Level lighting not adequate around equipment as well as in large equipment consoles. — Very small
2. Physical proximity between various equipment cabinets and the various maintenance resources (test equipment, spares) not close enough. — Very small
3. Climatic conditions degrade equipment inherent maintainability (heat, dust, humidity). — Small

C. General Base Policies

1. Defective modules (subassemblies and boards) are repaired at the base. — Medium
2. Failures not catastrophic to equipment operation and requiring short maintenance times are saved and fixed during periods of extended maintenance (PM). — Very small
3. Failures requiring less than three minutes corrective maintenance time are not recorded. — Very small
4. Stockrooms located at some physical distance from equipment require defective part to be turned in upon requisition of spare. — Small to Medium
5. Operational personnel instead of maintenance personnel perform corrective maintenance. — Very small

D. Equipment High Reliability

1. Systems having a low failure rate exhibit higher than expected corrective maintenance times. — Small to Medium

E. Base Adminstration

1. Preparation and cleanup times are included in field reported M_{ct}. — Very large

F. Equipment Design Features

1. Equipment used as intermediate processors (interfaces between two equipments) exhibits more CND conditions than does prime processing equipment. — Very small to Very large

<u>Factor</u>

Factors whose relative influence were extremely small on the equipments studied have been deleted from this summary but are included in body of report.

<u>NOTE</u>: $0 <$ very small ≤ 3 minutes
$3 <$ small ≤ 5 minutes
$5 <$ medium ≤ 10 minutes
$10 <$ large ≤ 15 minutes
15 minutes $<$ very large

As illustrated above, the operational influences were divided into four basic categories:

- Operational factors causing a disparity between the inherent corrective maintenance time (M_{ct}) (the M_{ct} exhibited by collecting field data under contractor control in which deviations from proposed support philosophy were screened) and the ideal base exhibited M_{ct}.
- Operational factors that affect the base to base to base M_{ct} (best base to worst base).
- Operational factors affecting the difference between base active M_{ct} and base reported M_{ct}.
- Operational and manufacturer factors resulting from variance between equipment types.

This factor identification formed the basis for modifying the current maintainability prediction model. The proposed model is as follows:

$$\text{Field Reported } M_{ct} = [Z_1] [Z_2] [\text{Manufacturers' Predicted } M_{ct'}]$$

where Z_1 represents the manufacturer's influences, and Z_2 represents the operational influences.

From this study, Z_1 typically is 1.20 and Z_2 is equal to 3.78.

The $[Z_1 \; Z_2]$ product is 4.536.

It must be noted that this model fits those bases and equipment data studied.

The approach utilized in deriving the model is universal in nature; however, the values for the various factors (Z's) are limited because:

- The Air Force sites visited were homogenous in purpose.
- Field data collection was limited to four systems even though the design/intent of the systems studies are variant in technology, design content, and system application.
- The field data collected was time period limited.

This study formed the basis for three basic observations:

- Field equipment availability is relatively unaffected (< 2%) by the reported corrected maintenance times which on the four equipments studied varied from 2.5 to 5.8 times the predicted MTTR. This is attributed to the extremely high field reliability of the systems studied; i.e., the systems are operated 24 hours/day with an average of 2.5 corrective maintenance actions/month. Thus, it may not be financially justified to invest large financial resources to minimize the field reported corrective maintenance actions.

- Maintenance technician proficiency is directly related to the amount of repair practice. With 3 shifts/day and the failure frequency occurrence discussed above, the degree of proficiency gained and displayed in a formal Maintainability Demonstration test (MIL-STD-471) when more than 50 samples are used, can never be achieved in the field without frequent periods of simulated failure generation and repair.

- Contractor assumed maintenance concepts (particularly module/assembly remove/replace philosophies) are in part not practiced in the field environment due to the large cost for the required module/assembly sparing inventory to support this concept. When these concepts are deviated from the remaining portions of the contractor's designed support concept (test capability, training, handbook thoroughness) are not compatible with the actual field practiced maintenance concept and thus increased repair times result.

One major recommendation is made as a result of this study. General operational influences attributed to equipment differences in design and support have been identified in this study; however, additional Air Force ground site types; e.g., strategic, tactical, mobile sites must be studied. In this study, seven bases were visited; although they were all of the same mission type, a significant degree of variances existed between these bases. Additional base types could provide additional influences existing between bases.

2. OBJECTIVE AND GENERAL APPROACH

This section generally describes the objective of the study and the general approach implemented to achieve this objective. Subsequent sections in the report describe in more detail the approach and backup data used.

2.1 OBJECTIVE

The objective of this study was to investigate and define the causes of the variation between the predicted and field-observed maintainability (M) of Air Force ground electronic equipment. It was the intent of this study to take these defined causes and develop a mathematical model which will permit an estimation of field time to repair based on the relative contribution of the various factors identified in this study.

2.2 GENERAL APPROACH

The approach used in identifying these factors and developing the mathematical model is illustrated in figure 1. Specifically, this approach is as follows:

- Identify systems to be studied and collect existing prediction, contractor field, demonstration, and Air Force Field Maintenance (66-1/65-110) data.
- Select a cross section of field sites for on-site investigations based on accessiblity to Westinghouse representatives and geographic variation and whose data appear to exhibit a representative mix of long, average, and short repair times.
- Generate questionnaires for Air Force field technicians for determination of actual field implemented maintenance polices including training, sparing, system testing, and other operational conditions.

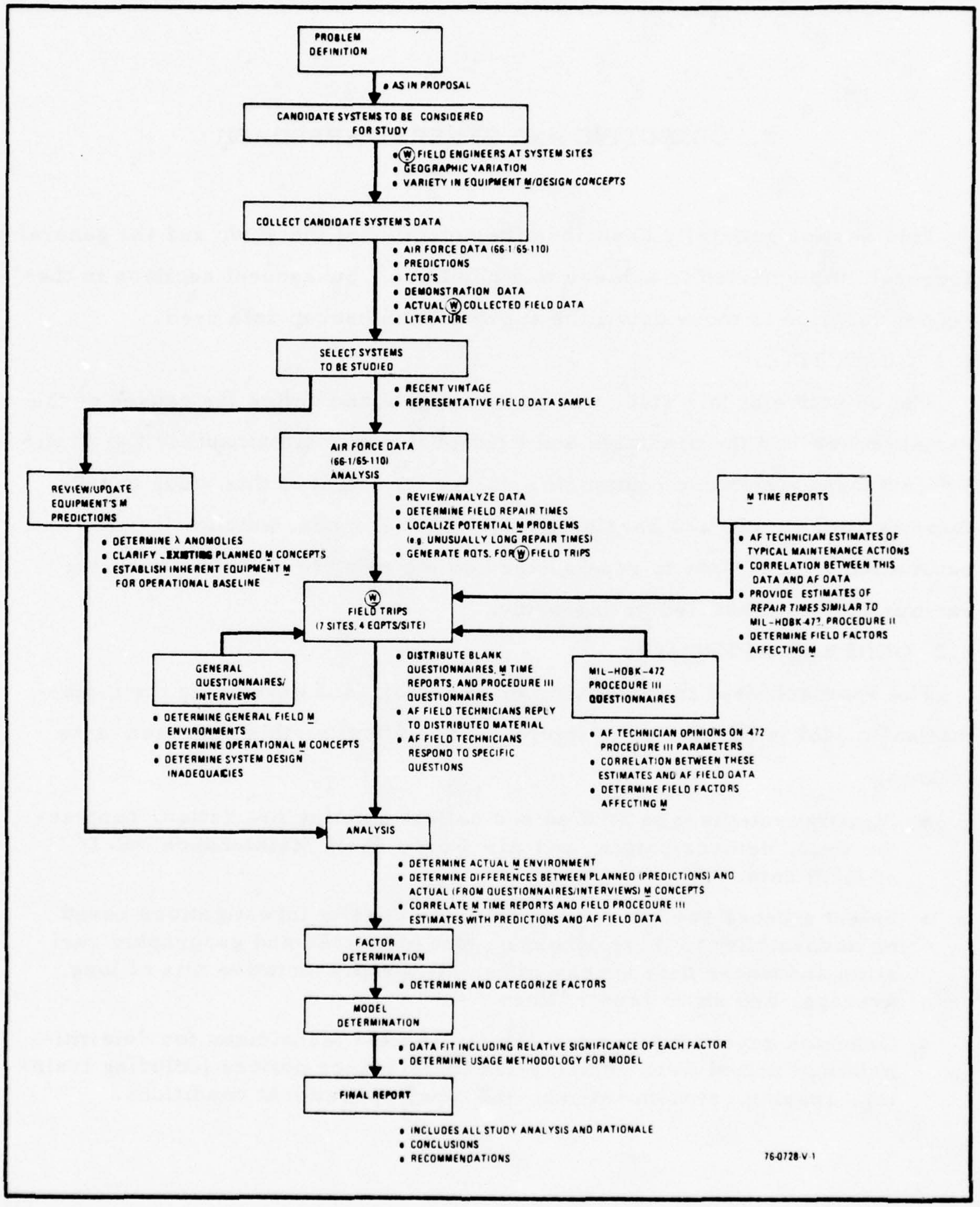

Figure 1. Operational Influences on Maintainability Study Approach

- Distribute Westinghouse developed $\underline{M}$ Time Reports (as illustrated in figure 2) and MIL-HDBK-472, Procedure III questionnaires to Air Force field technicians such that the technicians could complete these forms depicting either actual or typical maintenance actions.
- Analyze all the field data such that the various factors and their contribution to field repair time can be determined and modeled. Details of how each of these steps was implemented are given in the following paragraphs.

2.2.1 Selection of Systems To Be Evaluated

The first part of the program consisted of identifying the systems to be studied. The factors that influenced the preliminary system selection were:

- The ability of Westinghouse field engineers to visit and collect data at the sites of the candidate systems.
- The vintage of the systems (post 1967).
- A wide range of design and maintenance concepts.

Fourteen systems were identified as candidates for study. Table 1 is a listing of these systems. Once the systems were identified, data on them were collected. Air Force field data (both 66-1 and 65-110), prediction data, $\underline{M}$ demonstration data, actual contractor field data, and technical manuals were assembled. The data were analyzed and the four systems to be studied were selected. The systems selected, the AN/GPA-127(V), the AN/FYQ-47, the AN/FPS-27A, and the AN/GPA-124, represents samples whose existing field data are adequate to ensure completeness, quality, and quantity of data. The systems are located at an adequate number of geographically varied sites available to Westinghouse representatives and, are all of post-1967 vintage. The individual maintenance and design concepts for these systems are explicit but different, and their prediction, demonstration and contractor's field data are precise and well defined. Thus a good data baseline from which to operate is established.

MAINTAINABILITY TIME REPORT

FPS-27A ☐ FYQ-47 ☐ GPA-124 ☐ GPA-127 ☐

Date ______

Site:	Estimated Time	Typical Task Description	Actual Task Description
Preparation time (TP) Time spent in obtaining tools, test equipment, T.O.'s etc. necessary to begin troubleshooting the equipment.	______	Setup Tek 545 Scope Obtained extender board from storage cabinet Looking for soldering iron (new irons on order)	______
Fault Location/Verification Time (TD) Time spent in determining what has failed, also report time spent in verifying that the replaced part(s) actually correct the defect.	______	Noticed Fault Isolated fault to IF Receiver Made comparison checks on spare and suspect board Put suspect VGA on extender board, found SS bad. Installed repaired VGA	______
Item Obtainment Time (TI) Time spent in obtaining a part from base supply, also transportation time to obtain the part.	______	Obtained spare VGA from supply point Obtained 2N918 from supply	______
Fault Correction/Adjustment Time (TC) Time spent in removing the defective LRU and installing a new LRU. Also report time spent in adjustment of the failed LRU prior to checkout to see that the system actually is operable.	______	Verified that fault is in suspect VGA Took board to other shop to replace transistor Adjusted prior to checkout	______
Administrative Time (TS) Time between the beginning and end of work on a malfunction when no active maintenance is being performed	______	Opened job controls no. (JCN) Trying to borrow good iron to remove transistor Closed JCN	______
Checkout Time Time required to verify correct performance.	______	Verified VGA is ok with IF test targets and monitor console no. 1	______
Cleanup Time	______	Put Tek 545 Scope away	______

Comments:

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Figure 2. Maintainability Time Report Sample

TABLE 1

CANDIDATE SYSTEMS FOR STUDY

Equipment	Manufacturer	Vintage	Function
AN/GPA-124	Hazeltine	15 Sept '71	Coder-Decoder Group
AN/FSS-007	Arco	15 April '70	Detecting Warning Set
AN/GYK-019	Burroughs	15 Oct '68	Data Display Console
AN/FYQ-47	Burroughs	15 Feb '72	Digitizer/Transmitter
AN/FPS-026	Arco	1 March '62	Radar
AN/GRC-027	Collins	1 Nov '55	Radio
AN/FPS-006	General Electric	15 July '59	Radar
AN/GKA–005	RCA	15 Jan '69	Flight Control Group
AN/GPA-127 (V)	Bendix	1 Nov '67	Indicator Group
AN/UPX-021	Budd Electronics	15 Sept '63	Interrogator Set (Single Channel)
AN/FPS-090	General Electric	15 July '59	Radar
AN/UPX-014	Budd Electronics	15 Sept '63	Interrogator Set (Dual Channel)
AN/FPS-027A	Westinghouse	1 July '71	Radar Set

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2.2.2 Field Trip Preparation

After the four systems were selected, inherent and field M characteristics had to be determined for each system. The inherent/design M characteristics are defined in the equipment and planned maintenance concept descriptions and are reflected in the individual M predictions. The technical manuals for each system were reviewed and the equipment M design characteristics and planned maintenance concepts confirmed. M prediction data for the AN/FYQ-47 using MIL-HDBK-472, Procedure II and the AN/FPS-27A using Procedure III were available from previous manufacturer's reports. Predictions were made during this study for the AN/GPA-127(V) using Procedure II and the AN/GPA-124 using Procedure III. A previous AN/GPA-124 Procedure II manufacturer prediction had been made but was received too late to be used for this study. Comparison of this manufacturer prediction with the study prediction showed the manufacturer-predicted Corrective Maintenance Time (M_{ct}) to be less than 15

percent of that derived in the study prediction. Review of the manufacturer's predictions for the AN/FYQ-47 and the AN/FPS-27A resulted in their being purged of anomalies due to failure rate misrepresentation or M_{ct} estimation optimism. Section 6 discusses this influence factor.

After these system's "front-end" data were properly referenced, the Air Force field data were reviewed to identify sites which exhibited longer than average, average, and low repair times. A representative cross section of bases based on repair time mix as well as accessibility to Westinghouse representatives and geographic variation were selected for further evaluation since operational factors could be determined from this type of sampling. Westinghouse determined that seven Air Force sites would be visited. At these sites:

- Specific questions about the various repair times (especially the long ones) were answered by Air Force personnel.
- General maintenance environments including test and support equipment available, quantity and skill levels of technicians, equipment usage levels, and general base operating policies were determined.
- Actual or estimates of typical field repair actions were made similiar to those forecasted by the prediction processes made in MIL-HDBK-472 by having Air Force field personnel complete the $\underline{M}$ Time reports and the MIL-HDBK-472, Procedure III questionnaires.

These data along with the $\underline{M}$ demonstration data and contractor field data for the AN/FPS-27A provided the base on which the factor determination and modeling were developed.

2.2.3 Data Analysis

This phase of the program was spent in performing a detailed reduction of the data for factor identification and mathematical modeling. Field raw data, semiscreened data, and screened data were examined and compared with the $\underline{M}$ predictions for determination of differences and the causes of the differences. For this study, field raw data were defined as the total set of Air Force 66-1/65-110 data. The semiscreened data consisted of the 66-1/65-110 data separated into three basic groups. The first group was achieved by separating out data for which no

crew size could be determined. The other two groups were created when the data not assigned below the system level was separated from subsystem data. Details of this semiscreening are given in Sections 4 and 5 of this report. The screened data illustrated in Section 5 have all of the nonactive M_{ct}'s, namely administrative and part procurement times, "no-defect" times, mechanical repairs, and unusually long repair times, factored out of the semiscreened data. Once the differences between the data baseline (predictions) and the field data were determined, a modeling procedure was developed. This mathematical model for relating field repair times to predicted Mean-Time-To-Repair (MTTR) was divided into two basic parts. The first part consisted of confirming the relevancy of the prediction techniques in MIL-HDBK-472. This part of the model would be utilized for design guidance and would only be used to predict inherent $\underline{M}$. A second model was then developed. This model would be used to transform this inherent $\underline{M}$ (as predicted by MIL-HDBK-472 procedures) into forecasts for field repair times. These forecasts will reflect the influence of the various factors as determined on the field repair times.

3. DESCRIPTION OF SELECTED SYSTEMS

This section consists of a description of the four systems selected early in the study for in-depth evaluation. Size, weight, and design technology are among the elements discussed. These systems, the AN/GPA-127(V), AN/FYQ-47, AN/FPS-27A, and the AN/GPA-124 represent different design and support technologies spanning a design and usage period from October 1967 through the present. One study system employs vacuum tubes and uses an electro-mechanical servocontrol system for range indication; another is primarily a solid-state common digitizer with a large degree of Built-In Test (BIT). The third system under study evaluates maintenance on the RF/microwave portion of a 2-dimension stacked beam radar. The fourth system generates digital coder/decoder information used for aircraft interrogation. Specific details on the general description and intended use, physical charateristics, and the intended maintenance concept for each of the four systems are contained in the following paragraphs.

Table 2 lists the predicted Mean Time Between Failures (MTBF) of each of the four systems and, based on these, the anticipated failures of each during a month of full operation (720 hours). Since the MTBF's are high, failures occur infrequently. In fact, based on the predicted MTBF's, the number of anticipated monthly failures of an AN/FPS-27A (with the lowest MTBF among the four systems) is only 2.

$\underline{M}$ predictions were made on the systems being evaluated in this study. MIL-HDBK-472, Procedure II was utilized for the AN/GPA-127(V) and the AN/FYQ-47, and Procedure III was employed for the AN/FPS-27A and the AN/GPA-124. This section includes brief overviews of the predictions. Paragraphs 4.6.2 through 4.6.5 summarize the results of the predictions

TABLE 2

STUDY EQUIPMENT ANTICIPATED MONTHLY FAILURES

	AN/GPA-127(V)	AN/FYQ-47	AN/FPS-27A	AN/GPA-124 (less Computer)
Predicted MTBF (hr)	1021	663	370	1203
Anticipated Monthly Failures based on 24-hour operation (720 hr)	0.71	1.09	1.95	0.60

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for the individual systems.

3.1 AN/GPA-127(V) INDICATOR GROUP

3.1.1 General

The AN/GPA-127(V) Indicator Group is a console type Plan-Position Indicator (PPI) designed for use with long-range search radar systems. The function of the Indicator Group is to present azimuth and range location of either fixed or moving targets. Direction-finding signals and video-mapping information may also be presented on the indicator screen.

The Indicator Group consists of an Azimuth Range Indicator, and Electronic Control Amplifier, a Power Supply, a Display Board, and an Indicator Group Cabinet.

The Azimuth-Range Indicator IP-91( )/GPA-127(V) receives target video information, scanning information in the form of triggers, and auxiliary

inputs such as range marks, angle marks, IFF, and beacon video from a compatible radar set. Using these inputs, the indicator drawer produces a PPI display.

The Electronic Control Amplifier AM-389/GPA-127(V) controls the PPI sweep rotation through the use of synchro signals received from the compatible radar system. Control error voltage data keeps the sweep rotation of the PPI in synchronization with rotation of the radar antenna.

The Power Supply PP-552/GPA-127(V) develops regulated voltages of +300, -150, and +7,000 volts. These voltages provide operating voltages for all associated components of the Indicator Group.

Display Board MX-1061/GPA-(V) provides a lighted writing surface and is attached to the front of the cabinet.

Cabinet CY-821/GPA-127(V) houses the Indicator Group and provides interconnecting wiring for its components.

3.1.2 Hardware Description

The AN/GPA-127(V) Indicator Group is housed in a cabinet 45 inches high, 22 inches wide, and 43 inches deep. The total weight of this system is 412 pounds. As previously described and illustrated in figure 3, the Indicator Group consists of four removable assemblies and the main cabinet housing. Removal of any of these four assemblies for maintenance consists of removing the external fasteners (eight per assembly) used to secure the assembly in the cabinet. Once these fasteners are removed, the assembly is moved far enough out of the cabinet to disconnect the intrassembly cabling. Service loops permit this removal.

Electronically, the AN/GPA-127(V) consists primarily of discrete resistors, capacitors, vacuum tubes, and an electromechanical servocontrol system. Repair of any of these defective components requires removal of the particular assembly on which the defective component is mounted.

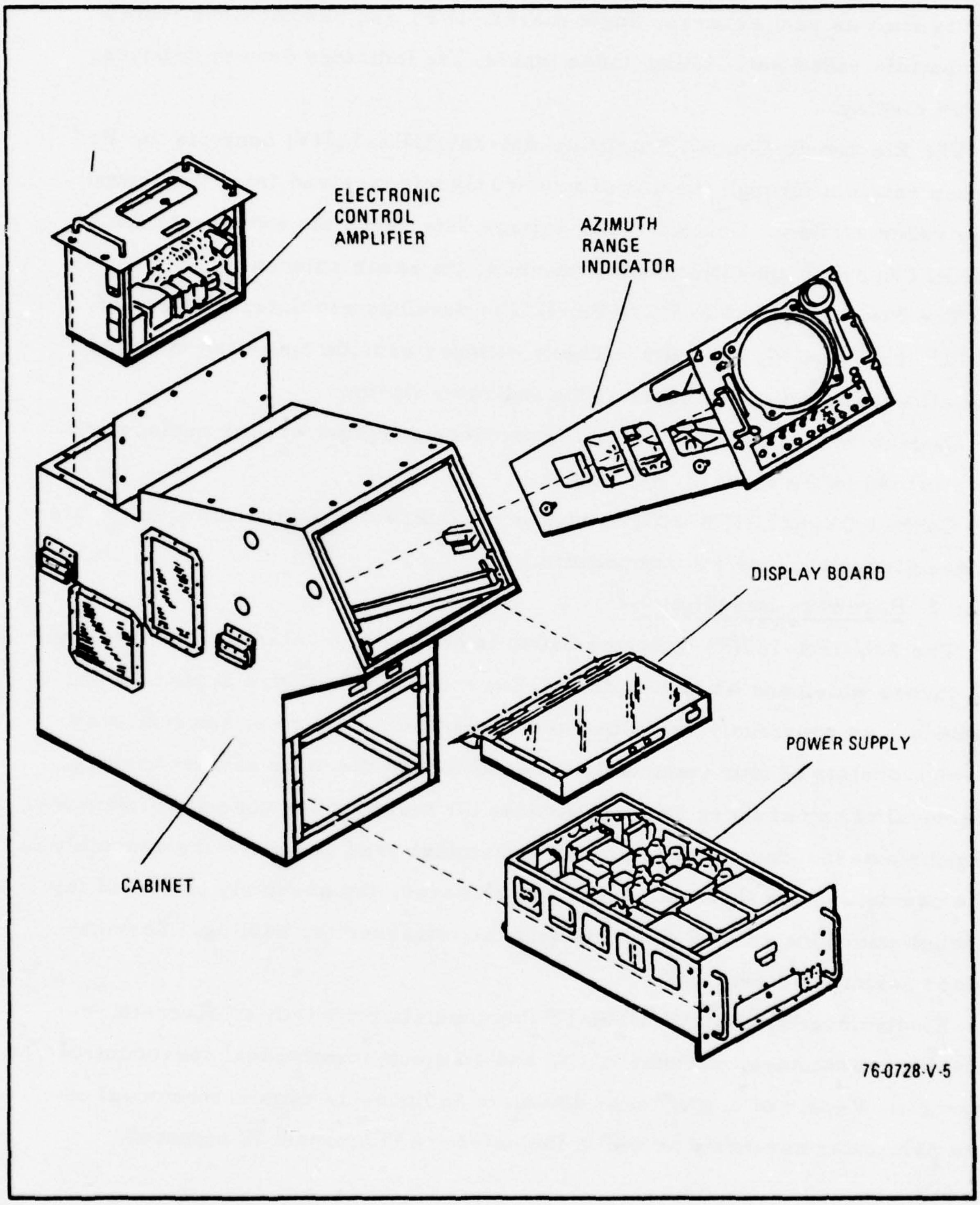

Figure 3. Indicator Group AN/GPA-127(V)

3.1.3 Maintenance Concept

The AN/GPA-127(V) maintenance concept consists of fault isolating to one of the four major assemblies through performance testing, removal of the defective assembly from the main cabinet, and subsequent fault isolation to the defective component on the bench. Spares provisioning for the AN/GPA-127(V) is at the component level only (i.e., resistors, capacitors, vacuum tubes, etc.), and thus each major assembly is maintained at the component level for repair. Troubleshooting of the system is designed to be performed by one Air Force skill level 5 technician, with a minimum of 2 weeks formal training on the equipment followed by 4 weeks of "on-the-job" training. This training is very important in the support of the AN/GPA-127(V) since this equipment has essentially no automatic BIT. This training provides the working knowledge of how the system is mechanized and how to maintain it upon failure. Test points, switches, lamps and fuses are located on the front panel of the major assemblies and throughout the units to help facilitate fault isolation. Once a major circuit has been fault isolated to, defective components are found by utilizing standard techniques such as voltage and resistance measurements or waveform analysis. No special test equipment is required for testing the AN/GPA-127(V). Only four pieces of standard test equipment are required:

- Oscilloscope - TS-239/U.
- Multimeter - TS-352/U.
- Tube Tester - TV-2/U.
- Pulse Generator - TS-592/U.

These systems are not supplied as part of the AN/GPA-127(V) suite but are assumed to be part of the normal deployment site inventory of test and support equipment. Additionally, any ground handling equipment such as transit dolly and straddle hoist required for moving the AN/GPA-127(V) in the field will not be supplied as part of the Indicator Group but are assumed available as part of the associated radar site.

No alignment or adjustment of the Indicator Group is necessary. Additionally, changing vacuum tubes throughout the units at regular intervals is not recommended. However, at 6-month intervals, the application of AN/G-25 type grease to the ball bearing assembly of the cathode ray tube mount is recommended. Table 3 summarizes the M analysis for the system. Also included in this table are a subassembly component analysis and a failure rate prediction. The failure rates were derived from MIL-HDBK-217B.

3.2 AN/FYQ-47 COORDINATE DATA TRANSMITTING SET

3.2.1 General

The AN/FYQ-47 Transmitting Set is a real-time common digitizer used by the Federal Aviation Agency and the Department of Defense to prepare digital data from raw video inputs. The equipment is located at Air Force long-range radar sites and receives inputs from AF radar, beacon, and associated equipment, performs statistical detection on these inputs to declare the presence of target aircraft, and prepares digital messages for telephone line transmission to remote central Air Force air defense processing centers.

3.2.2 Hardware Description

The portion of the radar processing equipment for the AN/FYQ-47 common digitizer evaluated in this study was the Electronics Unit (EU). As illustrated in figure 4, the EU is a standard, rack-mounted piece of equipment, containing over 770 plug-in digital printed circuit boards (PCB's) mounted on the pull-out doors of the cabinet. The EU is divided functionally into 15 groups for presenting and describing the functional operations of the EU. This functional division does not normally conform to the physical division of the cabinet, racks, and panels of the EU. Two or more functional groups may be contained within a single physical division, even through the groups are not related by their functional operations. Figure 5 illustrates the location of the Height Finder Common (HFC) module PCB's belonging to

TABLE 3

AN/GPA-127(V) RELIABILITY/MAINTAINABILITY SUMMARY

Unit	No. of Component	Failure Rate ($f/10^6$ hr)	M_{ct} (Minutes)*
Cabinet			
Chassis Mounted Parts	111	7.40	38.9
Blower Assy	1	42.50	62.0
Electronic Control Amplifier			
Chassis Mounted Parts	96	124.69	23.1
Azimuth Range Indicator			
Chassis Mounted Parts	132	389.70	42.4
Drive Coil Assy	1	0.05	54.0
Drive Coil Frame Assy	7	127.87	54.0
Off Center Coil Assy	5	1.04	54.0
Collector Ring Assy	No	Electrical	Parts
Capacitor/Resistor Assy No. 1	35	1.37	54.0
Capacitor/Resistor Assy No. 2	25	0.76	54.0
Resistor Assy	5	0.05	54.0
Capacitor/Resistor Assy No. 3	39	2.57	54.0
Capacitor/Resistor Assy No. 4	12	0.46	54.0
Capacitor/Resistor Assy No. 5	29	2.00	54.0
Capacitor/Resistor Assy No. 6	16	1.32	54.0
Power Supply	126	275.71	32.3
Display Board	5	1.64	15.4
Total	645	979.13	39.5

*Study prediction according to MIL–HDBK-472, Procedure II

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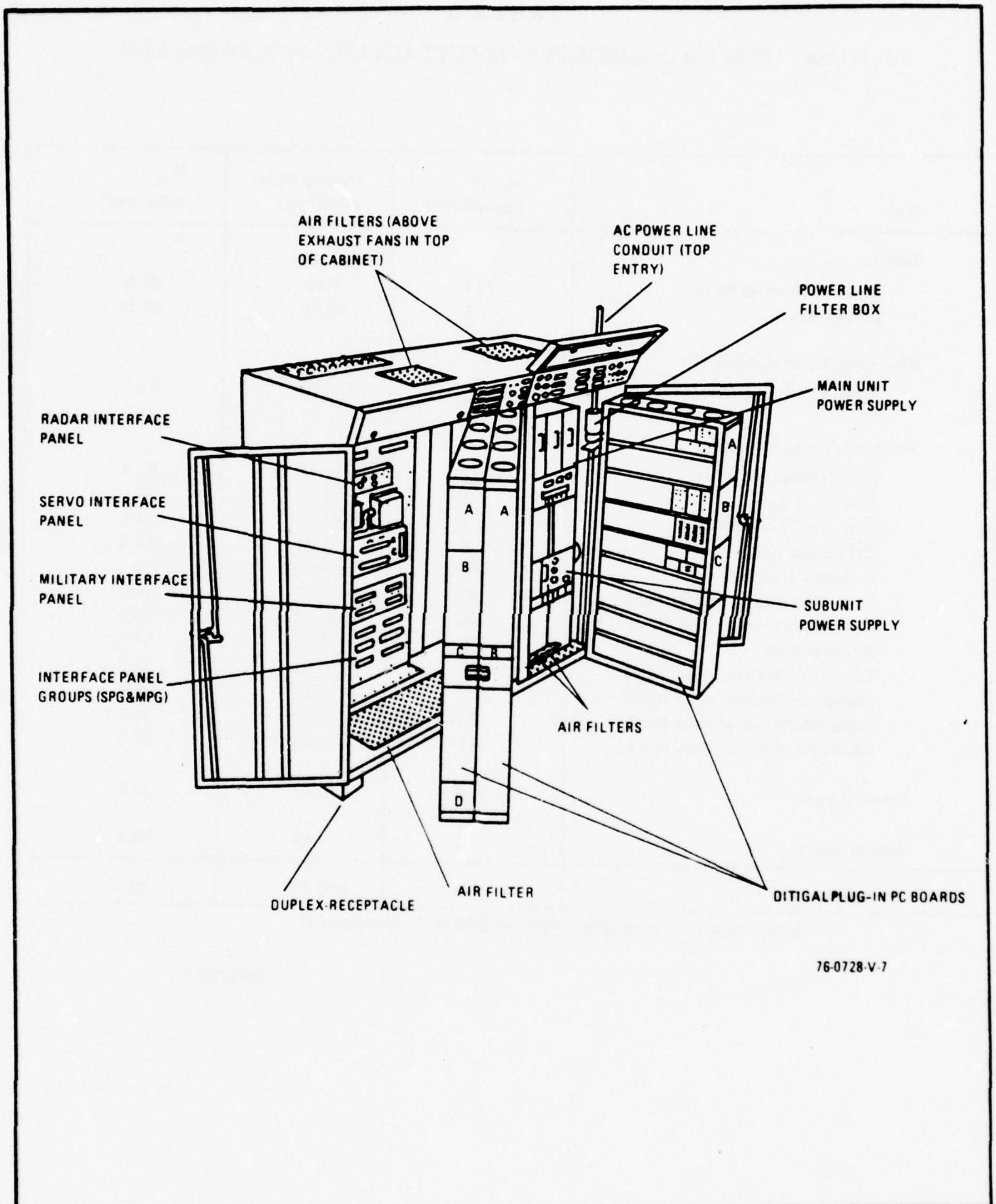

Figure 4. AN/FYQ-47 Electronics Unit Cabinet

PLUG-IN ASSEMBLY LOCATION CHART, MODULE ASSEMBLY 2-ROW

GROUP		SLOT	B	D	
A		0		14	
		1			
	•	2	1		
		3			
	•	4	2	15	•
		5			
		6			
		7			
		8	3	16	
		9			
B	•	0	4	10	
		1			
		2	5	17	
		3			
		4	5		
		5			
		6		16	
		7			
		8	3	9	
		9			
C		0	4	9	
		1			
		2	4		
		3			
	•	4	2	16	
		5			
	•	6	2	2	
		7			
		8		2	
		9			
D		0			
		1			
		2		16	
		3			
		4		18	
		5			
		6	3	11	
		7			
		8		19	
	•	9	6		
E		0		20	
		1			
	•	2	1	21	
		3			
	•	4	1	4	
		5			
	•	6	7		
		7		6	
	•	8	8		
		9			

GROUP		SLOT	B	D	
F	•	0	9	21	
		1			
	•	2	9	1	
		3			
	•	4	8	21	
		5			
	•	6	10	4	
		7			
	•	8	11	9	
		9			
G		0		10	
		1			
		2		1	
		3			
		4		9	
		5			
		6		18	
		7			
		8		17	
		9			
H		0		10	
		1			
		2		9	
		3			
		4		17	
		5			
		6		10	•
		7			
		8			
		9		22	
I		0			
		1			
		2		8	
		3			
		4		17	
		5			
		6			
		7			
		8			
		9			
J		0			
		1			
		2			
		3			
		4			
		5			
		6		18	
		7			
		8			
		9		23	
K		0			
		1			
		2		24	
		3			
		4	12	14	
		5			
		6	13	25	
		7			

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Figure 5. HFC Unit of Card Group 3

Card Group 3. This HFC represents a typical modular population in a card group. The 17 boards in this function are indicated by an astrisk next to their appropriate location in the rack. Typically, if one were to replace the HFC function, one would have to search throughout the rack for the 17 boards in order to replace them.

The EU is approximately 84 inches wide, 30 inches deep and 70 inches high. It weighs over 450 pounds. Input/output data are transferred over a main wiring harness which connects to the EU at the top of the cabinet.

Many maintenance features have been designed into the common digitizer equipment to aid in fault isolation and repair. Test target generators are incorporated in the equipment and enable maintenance personnel to exercise the internal processing functions with present target data. These targets enable the monitoring of equipment operations on a real-time basis. A similar operational checking function is provided by the Performance Monitoring Group (PMG) within the common digitizer. The PMG, using alarm circuitry and a status message generator, monitors critical signals and functions in various parts of the common digitizer and its associated external equipments. When an equipment failure or faulty operating conditions is sensed, an audible alarm is sounded and a status message is generated and sent to the computer control center. Additional BIT circuitry, under maintenance switch control, provides a core memory test, conditional system stop tests, and target detection and processing tests for the main functional equipments group of the common digitizer.

3.2.3 Maintenance Concept

The corrective maintenance concept employed for the common digitizer is:

- Determine that a malfunction exists by means of alarms and confidence checks.
- Utilize the equipment maintenance panels and logic diagrams to determine if the problem can be resolved to one or more groups of plug-in boards.

- Fault isolate and replace the defective board(s).
- Restore the defective board to an operational state off-line through the use of the AN/FYM-27 Electronic Circuit Plug-In Unit Test Set.

Excluded from the remove and replace approach are the hardwired components and assemblies (VD, PD, and MD cards, terminal boards, backplanes and portions of the power supplies), the ARM's (Antenna Rotation Monitor), and the ADC (Azimuth Data Converter) which are bolted down but electrically wired with connectors. The hardwired items are repaired by the removal and replacement of piece parts. Typically, if a fault was sensed and the alarm sounded, the maintenance technician would exercise several switches on the maintenance panel for test target generation. Through the use of recorders, PPI displays, and several test points, the problem would be localized down to an equipment function. The equipment is primarily divided into 30 semiautomatically isolated functions. If, for example, the Target Processing function was determined defective through the alarm/display mechanization, the maintenance technician would fault isolate to the defective board by employing the logic diagram illustrated in figure 6. Using the illustrated procedure, the technician could possibly replace as many as 101 plug-in PCB's if the fault was isolated to the MCG Card Group 5. However, when replacing plug-in boards during corrective maintenance, an incremental replacement technique is recommended for use with each card group function to aid in isolating the individual faulty board(s). This tends to reduce the total number of required replacements. As this description demonstrates, the AN/FYQ-47 digitizer is an extremely complex piece of digital equipment. The maintenance concept established for this equipment requires that the maintenance technician possess a thorough knowledge of digital hardware and a comprehensive understanding of the AN/FYQ-47 equipment and its maintenance procedures. As a minimum, two Air Force skill level 5 maintenance technicians with a minimum of 6 weeks formal AN/FYQ-47 training each are required to maintain this equipment in the deployed situation. Additionally, 4 weeks of "on-the-job" maintenance training are required.

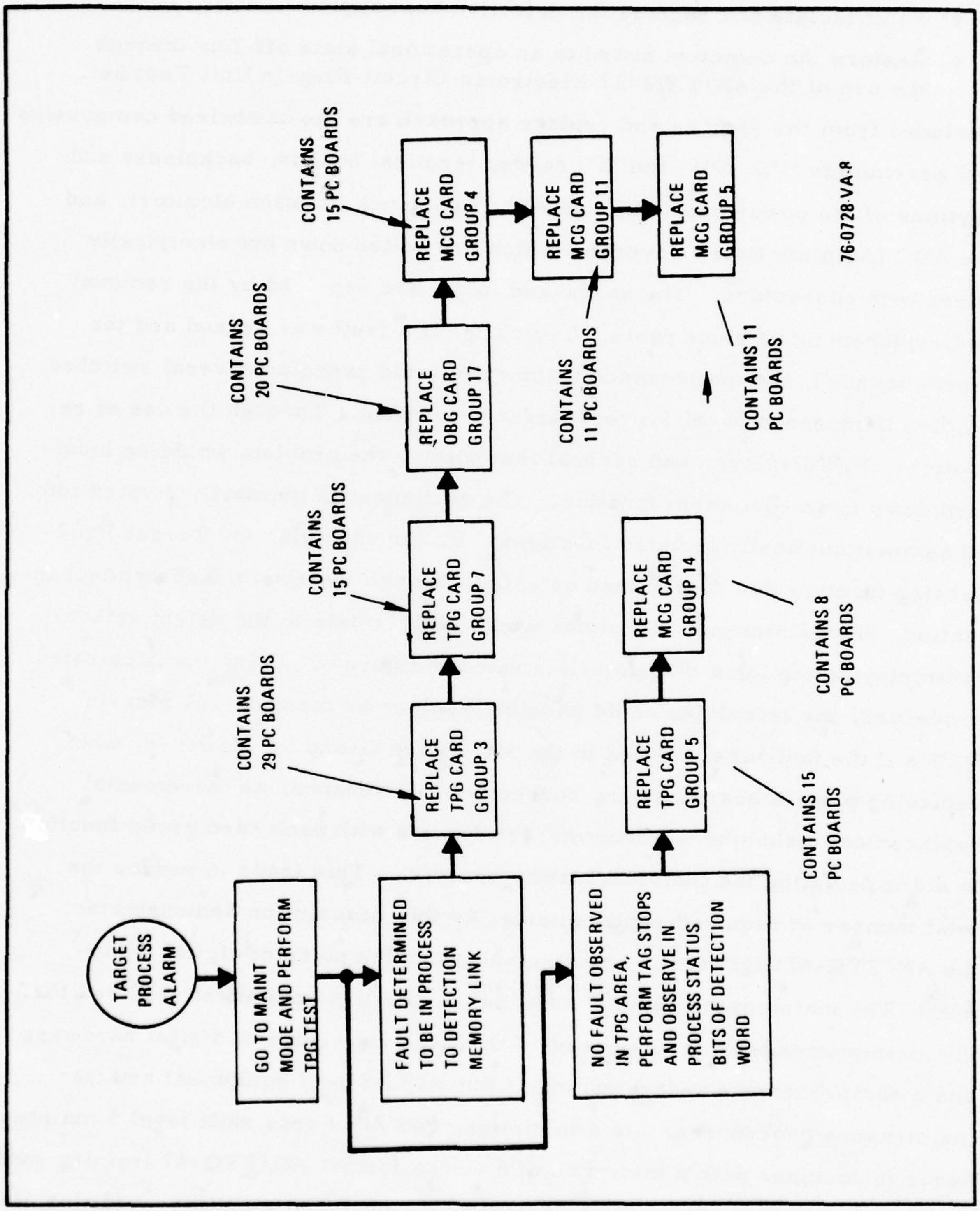

Figure 6. Target Processing Alarm Logic Fault Isolation Procedure

In addition to labor skill level and training, effective implementation of the maintenance concept requires a full array of replacement plug-in spare boards. These boards will have a twofold purpose in that they will be used for both troubleshooting the various equipment functions and restoring the system to an operational status through replacement of the defective board. Any deviation from this maintenance concept could result in long repair times.

There is no special test equipment required for maintaining the system. In cases where BIT can not isolate to one of the 30 groups, test points can be monitored with one or all of the following pieces of test equipment:

- Oscilloscope - Textronix 585A.
- Multimeter - Triplett 630 na.
- DC-AC differential voltmeter - Fluke model 803.
- Counter - Hewlett Packard 525A.
- VTVM - Hewlett Packard 400D.

Table 4 summarizes the $\underline{M}$ prediction for EU. Illustrated in this table are:

- The major functional groups of the AN/FYQ-47 EU.
- Their associated failure rates.
- The number of PCB's associated with each group.
- The M_{ct} for the EU and the major functional units.

3.3 AN/FPS-27A RADAR SET (MODIFICATION KIT)

3.3.1 General

The AN/FPS-27 is a ground based, high-power, 2-D stacked beam, frequency diversity search radar. The AN/FPS-27 supplies range and azimuth information on all targets through 360 degrees in azimuth to an altitude of 150,000 feet and a range of 220 nautical miles.

Multiple transmit frequencies are available on a dual transmitter system using a klystron final power amplifier. The transmitter system features TWT drivers, solid-state amplifiers and SF_6 waveguide pressurization.

TABLE 4

AN/FYQ-47 RELIABILITY/MAINTAINABILITY PREDICTION SUMMARY

Assembly Nomenclature	Part Number	Number of PC Boards	(f/10^6 hr)	M_{ct} (Minutes)*
HF/O–I-Height Finder Module	PL-1266	79	279.56	15.94
HFC–Height Finder Module	PL-1267	65	93.31	20.39
BRG/BWG – Beacon Reply Module	PL-1270	71	127.18	13.32
ARTG–Elect. Synch Module	PL-1271	105	81.32	18.54
TDG/MOG – Radar Target Detector	PL-1272	132	206.60	24.62
RQG – Quantizer Module	PL-1273	21	23.33	12.15
TPG/OBG – Output Buffer Module	PL-1268	182	253.24	20.11
MCG/MEM – Memory Control Module	PL-1269	114	249.44	24.70
ARM – Control Monitor	C-8351		38.28	29.46
Power Supply – Main Unit	PP-6349	3	101.19	61.07
Power Supply – Subunit	PP-6350	1	54.79	57.27

$\overline{M}_{ct} = 24.32$

*Manufacturers prediction according to MIL-HDBK-472, Procedure II

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The AN/FPS-27 receiver is a ten-channel system featuring MTI and ECM capability.

In order to upgrade the performance of these existing radars and to meet NORAD operational requirements, Westinghouse produced the AN/FPS-27A Mod Kit and modified 22 AN/FPS-27 radar systems. Major modifications include the addition of a Coded Pulse Anti-Clutter System (CPACS), Side Lobe Blanking (SLB) capability, and a Digital Moving Target Indicator (DMTI). CPACS is a technique to compress the received pulse in order to have an effectively smaller range cell and thus reduce the apparent radar clutter.

The modification kit includes two SLB reflectors, one SLB horn, the required modifications to the frequency generator for implementation of CPACS to the system, and modifications to the antijamming and monitor consoles to update video displayed and control circuits.

3.3.2 Hardware Description

As illustrated in figure 7, the AN/FPS-27 system is housed in a four-story structure 55 feet square and is topped by an inflatable aerodome which measures 55 feet in diameter at its base.

The equipment evaluated in this study (included in figure 8) consists of those portions of the modification kit included in the microwave receiver which provide the detailed RF-IF processing and the signal processor which includes the CPACS, DMTI and SLB functions. This equipment is located in the fourth story of the structure. The Microwave Cabinet is a standard 30-inch wide, 70-inch high rack-mounted cabinet and includes 14 RF, and IF dual conversion receiver channels. This cabinet contains 103 PCB's and 1 power supply which, when determined defective, are removed from the cabinet for repair. This cabinet provides the COHO Lock Pulse channel and BIT features such as MDS (Minimum Detectable Signal) measurement and Noise Figure monitor.

The Signal Processor Cabinet consists of two standard 30-inch wide, 70-inch high rack-mounted cabinets bolted together to provide one cabinet. This cabinet contains 41 PCB's and one power supply.

The left half of the cabinet contains the IF receiver cabinet which houses CFAR receiver channels and phase detectors for the primary signal flow, and fourteen log channels (ten radar and four reference) to provide the SLB receiver function. Included also are monitor features for aligning gains and slopes of the various IF channels.

The right half of the Signal Processor cabinet contains the digital cabinet housing six DMTI channels, the Normal channel, destagger, integrator, and synchronizer. In addition, built-in video test modes are included.

All power supplies and power distribution hardware are mounted inside their respective cabinets.

3.3.3 Maintenance Concept

The maintenance of the AN/FPS-27A consists of the following:

- Fault isolation to a defective plug-in PCB, planar array board, and/or RF assembly via BIT and through the use of external test equipment.

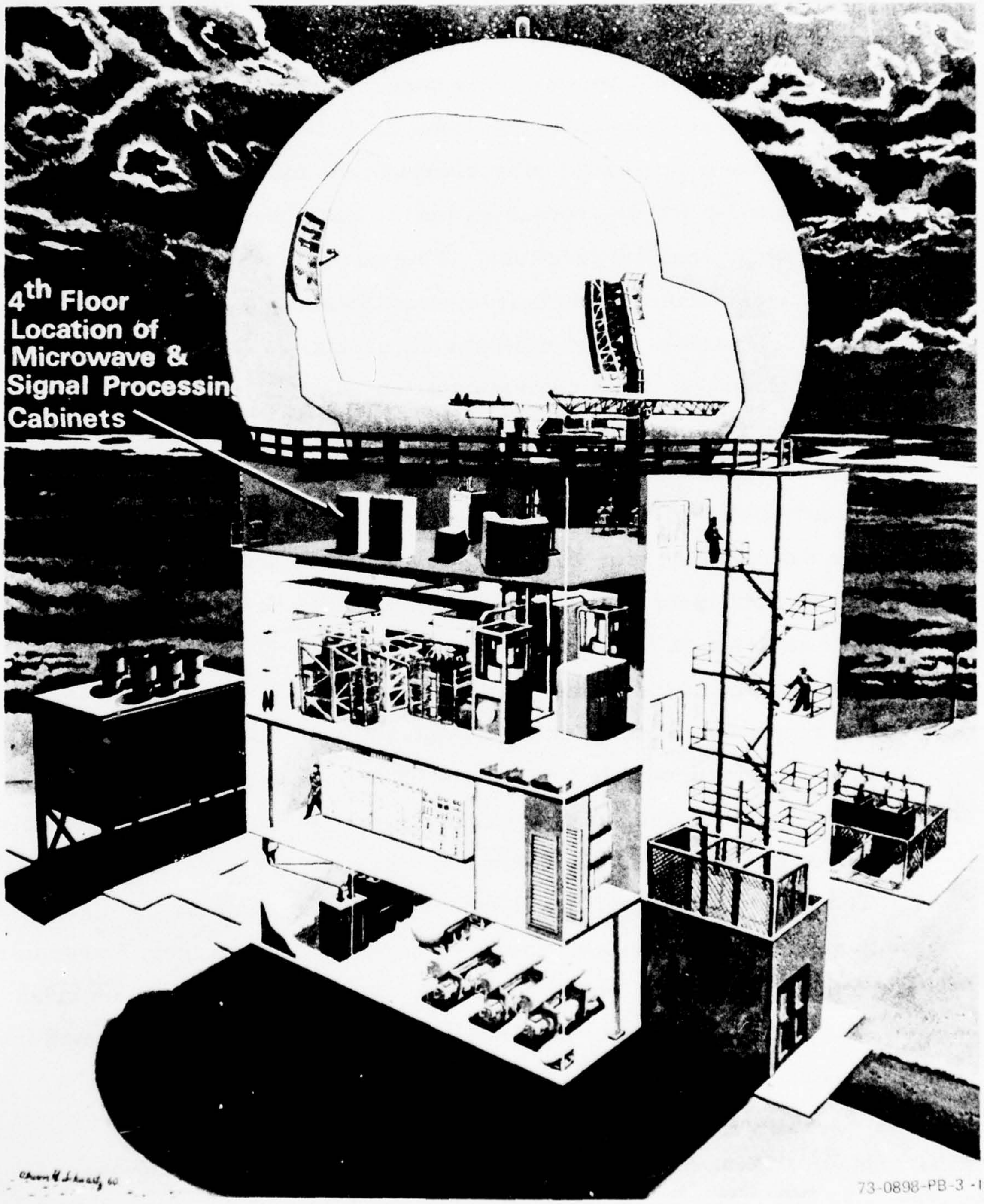

Figure 7. AN/FPS-27 Radar Set

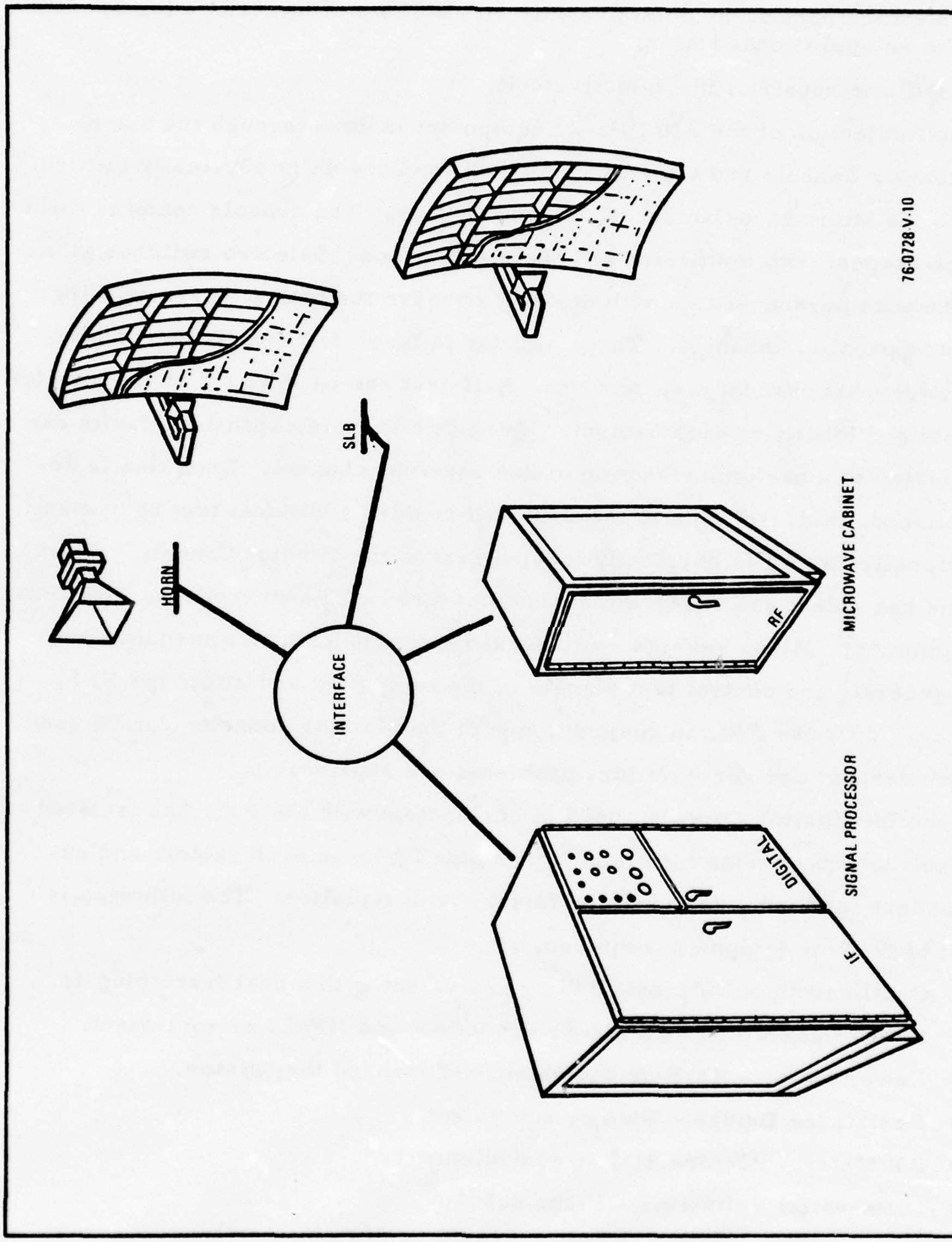

Figure 8. AN/FPS-27A Modification Kit

- Replacement of the defective unit with a like unit to restore the system to an operational status.
- Off line repair of the defective unit.

Fault detection of the AN/FPS-27 equipment is done through the use of the Monitor Console and the PPI. The Monitor Console is physically located next to the Microwave Cabinet on the fourth floor. The console contains three A-type scopes: two multitract and one single trace. Selectro switches allow maintenance personnel to simultaneously observe the data at corresponding points in parallel channels. Thus, similar failures are equally detectable no matter what channel they occur in. Self-test can be initiated at the monitor console and locally at each cabinet. Using this built-in capability, faults can be isolated to a particular section of one receiver channel. Once this is accomplished, fault isolation to the LRU will require additional test equipment. Additionally, a PPI is physically located next to the Monitor Console. From it, one can select and observe the radar picture being sent from the AN/FPS-27 equipment. Also, several switches and controls at the maintenance console generate and control test signals in the equipment and affect the PPI display. Thus the PPI, in conjunction with the Monitor Console, can be used to troubleshoot and verify failure problems and repairs.

Once the Monitor Console, used in conjunction with the PPI, has isolated the fault to a particular function, fault status lights in each cabinet and external test equipment are used for further fault isolation. The following is a list of the test equipment required.

- Oscilloscope - Tektronix 545 or equivalent with a dual trace plug-in.
- Signal Generators - HP616 or equivalent and HP608 or equivalent.
- Power Meter - 431B or equivalent with S-band thermistor.
- Resistance Bridge - ZM4 or equivalent.
- RF Meter - Boonton 91C or equivalent.
- Differential Voltmeter - Fluke dc901.
- Spectrum Analyzer - AN/UPM-84A or equivalent.
- Frequency Counter - 5245L or equivalent with plug-ins.

- Multimeter - HP410.
- Scope Accessories, coax connector adapters, terminators.

This standard test equipment is supplied by the Air Force.

The maintenance concept for the AN/FPS-27A is predicated on the availability of replacement PCB's, planar array boards, RF assemblies, and the efficient use of the fault isolation scheme. Use of the fault isolation scheme depends largely on the maintenance technicians utilization of the test equipment. For the AN/FPS-27A modification kit, 2 weeks of formal training to a Air Force skill level 5 technician are recommended. Additionally, 1 month of supervised "on-the-job" training is recommended. An average of two maintenance technicians are required for each corrective maintenance task. One technician will monitor and control the monitor console and PPI; while the second will use the test equipment for cabinet fault isolation. Table 5 summarizes the $\underline{M}$ prediction data for this hardware. Illustrated in this table are the names of potential board faults, their relative weight or frequency of repair based on failure rate, the questionnaire checklist scores for each fault analyzed, and the resulting predicted M_{ct}.

3.4 AN/GPA-124 CODER/DECODER GROUP

3.4.1 General

The AN/GPA-124 system generates a coded interrogation pulse continuously radiated to all aircraft within an area of radar surveillance. This system is integrated with an existing Selective Identification Feature (SIF) subsystem installation at a radar site. Encoded response pulses, or lack thereof, from the subject aircraft are processed and decoded by the AN/GPA-124. The resultant information is sent to the associated radar and Identification Friend or Foe (IFF) processor for display on the radar scopes.

TABLE 5

AN/FPS-27A $\underline{M}$ PREDICTION SUMMARY

Fault Item	Relative Wt.	Checklist Score A	B	C	Predicted M_{ct} (minutes)*
1. RF Amplifier	1	37	24	31	35
2. Mixer Amplifier	1	37	24	31	35
3. RF Power Supply	1	54	26	34	9
4. VGA	2	49	24	31	19
5. Channel Board	5	49	24	31	19
6. CFAR Channel Bd.	1	49	24	31	19
7. Phase Detector	1	49	24	31	19
8. A/D Converter	3	49	24	31	19
9. Video Amplifier	1	49	24	31	19
10. Memory	10	41	24	29	30
11. Arith. CFAR	1	41	24	29	30
12. IF Power Supply	1	54	26	34	9
13. DF Power Supply	1	54	26	34	9
14. Synchronizer	1	47	24	29	20
System Total	-	45.1	24.1	31	23

*Manufacturer's prediction according to Mil-Hdbk-472, Procedure III.

3.4.2 Hardware Description

The AN/GPA-124, as illustrated in figure 9, is an assembly of four distinct individual electronic units: the Operational Control Box, the Master Control Box, the Electronic Counter Counter Measure (ECCM) Box, and the Coder/Decoder Unit.

The Operational Control Box is a 6 inch x 6 inch x 6 inch box which provides remote operation of the Coder/Decoder Unit via cables. It weights 2.75 pounds and has a fault light and test points mounted on its front panel which are utilized for fault detection and isolation. It initiates interrogations and selecting video format for display. Components are mounted on a mother plate inside this unit.

The Master Control Box is 8 inches x 6 inches x 9 inches in size and weighs 6.5 pounds. This unit's components are mounted on a mother assembly within the box. The Master Control Box initiates interrogations and permits the selection of video format for display. The unit detects a fault via lights and a three time alarm in the Coder/Decoder Group.

The ECCM box is 4 inches x 5 inches x 4 inches in size and weighs 0.5 pound. Its components are also mounted on a mother plate.

The Coder/Decoder Unit case houses the interconnecting, processing, control indicating, synchronizing, and computing subsystems. This unit is 30 inches x 19 inches x 26 inches in size, weighs 267 pounds, and is of solid-state design. It is compositely made up of 105 PCB's easily removable from their particular chassis once the chassis is removed from main Coder/Decoder Unit. Removal of a main functional chassis consists of removing the fasteners (generally 8) from the front of the unit and sliding the chassis out of the cabinet via built-in slide rails. Once the chassis is partially slid out, the unit can be further fault isolated and the particular defective PCB removed.

3.4.3 Maintenance Concept

The maintenance concept for the AN/GPA-124 consists primarily of fault isolating to a defective box (Master, Operator, ECCM, or Coder/Decoder)

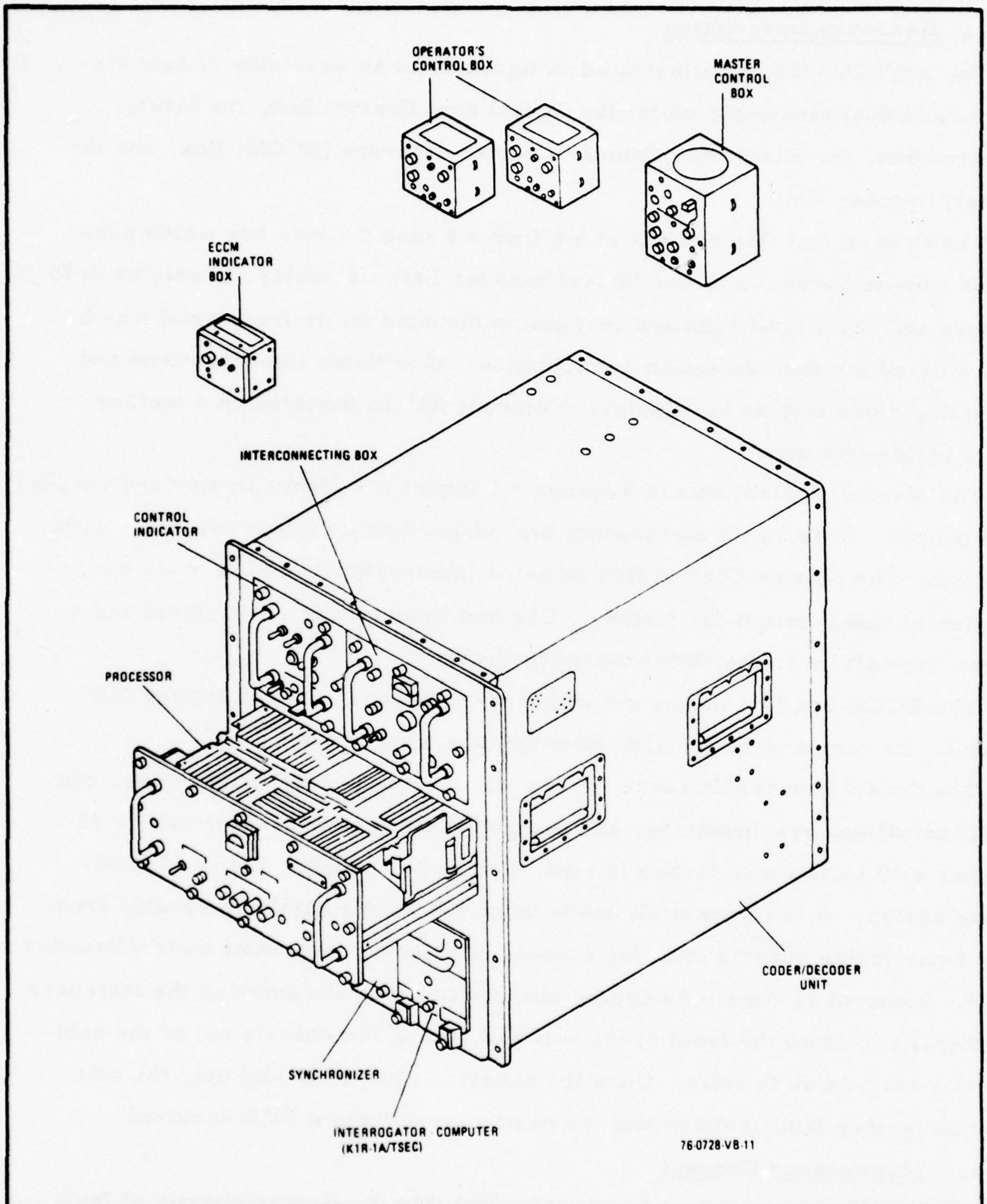

Figure 9. AN/GPA-124 Coder/Decoder Group

via BIT and subsequently to a removable PCB. In the Coder/Decoder Unit, subsequent fault isolation to the removable PCB is accomplished by standard test equipment. The defective PCB in the case of the Coder/Decoder Unit and/or the defective Master, Operator, or ECCM box is replaced with an operational spare, and the defective PCB or box is repaired "off-line". Repair of these consists of replacement of component parts.

The maintenance concept for this AN/GPA-124 unit requires a working knowledge of the system and digital equipment. As a minimum, two Air Force skill level 5 maintenance technicians with a minimum of 3 weeks formal AN/GPA-124 training each are required. Additionally, 2 weeks of "on-the-job" training are required.

To ensure compliance with the maintenance concept, a full set of spare PCB's for board replacement upon failure is required. Without this, down-time will be compromised. Additionally, replacements for the Master, Operator, and ECCM boxes are required. There is no peculiar test equipment required for fault isolating. The following is a list of the standard test equipment needed for fault isolation to a defective PCB. It is assumed that this equipment will be supplied by the Air Force at the development site:

- Oscilloscope - Textronix 585A.
- Multimeter - Triple 630NA.
- Counter - Hewlett Packard 525A.
- VTVM - Hewlett Packard 400D.
- Signal Generator - HP616.

Table 6 summarizes the $\underline{M}$ prediction used for this study. Illustrated in this table are the following:

- The relative weight of each unit's M_{ct} based on the fault rate distribution.
- The number of parts in each unit.
- The basic M_{ct} prediction as derived from the MIL-HDBK-472, Procedure III questionnaire.

TABLE 6

AN/GPA-124 MAINTAINABILITY PREDICTION SUMMARY

Unit	Number of Components	Relative Weight (%) (Based on λ)	M_{ct} (Minutes)*
Coder – Decoder Unit			
Electronic Synchronizer – 1A1	982	24	46.7
Signal Data Processor – 1A3	1,697	48	45.4
Control Indicator – 1A4	49	1	77.8
Interconnecting Unit – 1A5	769	23	57.8
Operator's Control Box – 2	18	1	30.9
Master Control Box – 3	76	4	41.3
$\overline{M}_{ct}$		Average =	48.8

*Study prediction according to MIL-HDBK-472, Procedure III

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A previous AN/GPA-124 Procedure II manufacturer prediction had been made but was received too late to be used for this study.

4. DATA BASE

This section presents and discusses the data used in the study. It also discusses the general existing environment from which the data were derived. The data used in this study were derived from eight basic sources:

- Air Force Field Maintenance Data collected per AFM 66-1 and 65-110.
- Westinghouse field questionnaires.
- $\underline{M}$ Time Reports/MIL-HDBK-472, Procedure III questionnaires.
- $\underline{M}$ Demonstration Test data.
- Contractor Collected field data.
- Equipment $\underline{M}$ predictions.
- Equipment Technical Orders (T.O.'s).
- Air Force Squadron capsule description.

Paragraphs 4.1 through 4.8 of this report discuss the purpose for collecting this data, present the data in summarized form, and edit the data in some cases to give a better overall picture of the collected data in preparation for subsequent analysis.

As stated in paragraph 2.2.2, Westinghouse field engineers visited seven Air Force sites. The data collected for this study came primarily from these seven sites which will be identified in this report as A, B, C, D, E, F, and G. The Air Force field data collected per AFM 66-1 and 65-110 came from these sites plus an additional 25 to ensure statistical significance in the quantitative data being analyzed.

4.1 AIR FORCE MAINTENANCE DATA

4.1.1 General

In order to analyze M_{ct}'s for maintenance actions performed in the field and make conclusions based on this analysis, an adequate data base is required.

Air Force 66-1 and 65-110 field data provided the base for this study. Data for the period 1 July 1973 through 30 June 1974 were collected from up to 32 Air Force operating squadrons via magnetic tapes procurred from HQ AFLC, Wright-Patterson AFB, Ohio. Table 7 summarizes the number of data entries collected on each equipment over this period. The composite data from which table 7 was derived came from the analysis of the 66-1 and 65-110 data summaries.

As shown in table 7, the data derived from the 66-1/65-110 source were divided into three basic catagories:

- Subassembly data with crew size (a).
- System data with crew size (b).
- Data for which no crew size could be established (c).

Crew size establishment in this analysis is extremely important since with this, average repair times and maintenance man-hours per corrective maintenance task can be established. The system data illustrated in table 7, could not be broken down to the subassembly level due to 66-1/65-110 recording anomolies such as incorrectly recorded Job Control Numbers (JCN's) and incomplete JCN forms. This system data, therefore, cannot be used to reflect typical corrective maintenance tasks whose MTTR's would be predicted by a MIL-STD-472 procedure, since the predictive techniques address subassembly (and lower) type maintenance actions.

It should be noted that, in general, EMT's can be taken directly from the 65-110 data and man-maintenance hours from the 66-1 data.

4.1.2 Data

Following correlation of the records and identification of EMT's, crew size, and man-maintenance hours per corrective task, an M_{ct} analysis for each system under study was made. Table 8 summarizes this correlation and analysis for all the subassembly data to which a crew size (maintenance

TABLE 7

AIR FORCE FIELD MAINTENANCE DATA (66-1/65-110) SUMMARY

Equipment	Number of AF Squadrons Evaluated	(a) Subassembly Data With Crew Size		(b) System Data With Crew Size		(c) No Crew Size Data		Overall Field Mct (a)+(b)+(c)
		No. of AF Field Recorded Events	Total Correct Maint Time (hr)	No. of AF Field Rc'd Events	Total Corr. Maint Time (hr)	No. of AF Field Rc'd Events	Total Correct Maint Time (MMH)	Minutes
AN/GPA-127(V)	20	142	351.3	27	70.1	27	127.4	168
AN/FYQ-47	10	170	344.8	23	99.9	7	26.8	141
AN/FPS-27A	7	90	167.4	29	46.7	1	2	108
AN/GPA-124	32	71	110.1	73	179.1	0	0	120

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team) could be assigned to the individual corrective maintenance action. In deriving this table, the data were consolidated at the lowest Work Unit Code (WUC) field-observed levels. EMT's have been summed to this level to include times spent in such maintenance activities as troubleshooting, repair, remove and replace, and alignment/adjustment. By totaling EMT's and dividing by the number of JCN's, an average time was derived for each failure correction. The JCN is used by the Air Force maintenance reporting system to chronologically group a sequence of actions generally relating to a single equipment deficiency. The activity recorded on a JCN may span a time of hours to weeks or even months. Table 8 only illustrates data to each system's second level of assembly. In this table, system totals were computed for the AN/GPA-124 and AN/GPA-127(V) systems; however, only the EU cabinet for the AN/FYQ-47 and the Receiving System for the AN/FPS-27A were illustrated, since the remaining

portions of these systems were not evaluated in this study. Two numbers are displayed in table 8: the average time per JCN ($\bar{M}_{ct}$) and the total number of JCN's for that equipment at a particular squadron from 1 July 1973 through 30 June 1974.

4.2 WESTINGHOUSE FIELD QUESTIONNAIRES

4.2.1 General

In this study, Westinghouse required a means to get actual field usage appraisals by Air Force maintenance techniques about the systems being studied and to get the actual practicing logistic support concepts being implemented in the field on the systems under study. By doing this, the quantitative data collected (66-1/65-110 and contractor numerical data) could be analyzed and screened where necessary such that the actual field operational influences affecting $\underline{M}$ could be identified. The vehicle for collecting this qualitative data was the Westinghouse questionnaire. Sixty-seven questionnaires were collected from the seven sites. Table 9 summarizes the number of questionnaires collected per equipment on each base.

4.2.2 Questionnaire

The Westinghouse questionnaire is divided into eight basic sections. Section I, "General", addresses the methods of recording failures by Air Force personnel in the field, the general inherent equipment characteristics, and the operational environment in which the equipment is used. In this way, the operational $\underline{M}$ characteristics for a particular base could be assessed.

Section II addresses the design features of the prime equipment under study. Access, location, andother physical characteristics are stressed here. Sections III through VII deal primarily with the maintenance concept being practiced and its supporting elements; i.e., tools, spares, handbooks, personnel, and test equipment. In these sections the following maintenance support elements are addressed:

- Level and extent of equipment BIT.
- Level and degree of assembly/subassembly remove, replace, and repair.

Equipment															Mc	
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	
AN/GPA-127(V)																
Cabinet						2.0/ 1	3.0/ 1									
Electronic Control Amplifier	0.6/ 2		0.5/ 1		1.2/ 7	0.4/ 2	0.9/ 4						1.8/ 2			
Azimith Range Indicator	5.5/ 8		3.3/ 1		5.6/ 8		5.9/ 4						1.5/ 1			[illegible]
Power Supply	0.1/ 1				1.9/ 5		0.5/ 1		1.0/ 1							
Display Board Totals	4.1/ 11		1.9/ 2		3.1/ 20	0.8/ 3	3.1/ 10		1.0/ 1				1.7/ 3			[illegible]
AN/FYQ-47																
Electronics Unit Cabinet	3.0/ 11	2.0/ 10	3.2/ 14	0.6/ 6	2.4/ 14					0.8/ 16	1.8/ 15	3.3/ 31	1.4/ 40			
AN/FPS-27A																
Receiving System	1.2/ 17	0.5/ 8	3.2/ 21	2.0/ 21	0.7/ 5					0.5/ 6						
AN/GPA-124																
Coder-Decoder Unit Electronic Synchronizer				1.0/ 2	1.3/ 6			0.4/ 2				0.2/ 1		0.3/ 1		[illegible]
Interrogator-Computer																[illegible]
Processor																
Control Indicator																
Interconnecting Unit							0.5/ 1	2.0/ 1	0.1/ 1		0.1/ 1				0.6/ 2	
Operator's Control Box										0.3/ 1						
Master Control Box																
TOTALS				1.0/ 2	1.3/ 6		0.5/ 1	0.9/ 3	0.1/ 1	0.3/ 1	0.1/ 1	0.2/ 1		0.3/ 1	0.6/ 2	[illegible]

TABLE 8

AIR FORCE FIELD CORRECTIVE MAINTEN

Mct Per Job Control Number/Squadron-Hours																					
O	P	Q	R	S	T	U	V	W	X	Y	Z	A'	B'	C'	D'	E'	F'	G'	H'	I'	J'
										1.3/ 1						0.6/ 1				6.0/ 1	0.7 1
								0.5/ 3								0.7/ 7	0.6/ 3	1.2/ 7	1.5/ 5		2.1 2
	4.3/ 4								1.8/ 4	0.8/ 3						5.2/ 2	5.1/ 8	1.1/ 9	4.9/ 2	2.7/ 4	3.6 8
								1.6/ 1									0.9/ 1		1.4/ 3		
	4.3/ 4							0.8/ 4	1.8/ 4	0.9/ 4						1.6/ 10	4.1/ 12	1.1/ 16	2.3/ 10	3.4/ 5	3.1 11
	0.2/ 1	2.4/ 2		14.5/ 2		2.7/ 4		1.3/ 1	0.9/ 1	0.2/ 1	0.1/ 1				0.5/ 1						
	0.5/ 1	0.1/ 1			0.1/ 1	1.6/ 8				0.2/ 1	0.2/ 3	0.2/ 2									
			0.3/ 2	2.0/ 4	0.1/ 1	0.2/ 1	3.4/ 3		0.4/ 2		0.1/ 1										3. 3
						2.0/ 1							1.4/ 1								
0.6/ 2		1.0/ 1				1.3/ 2							6.2/ 1	0.6/ 1							
									0.4/ 1												
									0.5/ 1												
0.6/ 2	0.4/ 2	1.5/ 4	0.3/ 2	6.1/ 6	0.1/ 2	1.8/ 16	3.4/ 3	1.3/ 1	0.5/ 5	0.2/ 2	0.2/ 5	0.2/ 2	3.8/ 2	0.6/ 1	0.5/ 1						3. 3

2

TABLE 8

AIR FORCE FIELD CORRECTIVE MAINTENANCE TIME SUMMARY

...urs																		
V	W	X	Y	Z	A'	B'	C'	D'	E'	F'	G'	H'	I'	J'	K'	L'	M'	Avg.
			1.3/ 1						0.6/ 1				6.0/ 1	0.7/ 1		3.4/ 1		2.43/ 7
	0.5/ 3								0.7/ 7	0.6/ 3	1.2/ 7	1.5/ 5		2.1/ 2	2.1/ 2	0.5/ 2		1.05/ 49
		1.8/ 4	0.8/ 3						5.2/ 2	5.1/ 8	1.1/ 9	4.9/ 2	2.7/ 4	3.6/ 8	7.0/ 1	1.3/ 2	2.0/ 6	3.66/ 71
	1.6/ 1									0.9/ 1		1.4/ 3				0.7/ 1	4.5/ 1	1.53/ 15
	0.8/ 4	1.8/ 4	0.9/ 4						1.6/ 10	4.1/ 12	1.1/ 16	2.3/ 10	3.4/ 5	3.1/ 11	3.0/ 3	1.3/ 6	2.4/ 7	2.47/ 142
																		2.03/ 170
																		1.86/ 90
	1.3/ 1	0.9/ 1	0.2/ 1	0.1/ 1				0.5/ 1										2.27/ 26
			0.2/ 1	0.2/ 3	0.2/ 2													0.77/ 15
3.4/ 3		0.4/ 2		0.1/ 1														1.46/ 14
						1.4/ 1												1.7/ 2
						6.2/ 1	0.6/ 1											1.3/ 11
		0.4/ 1																0.35/ 2
		0.5/ 1																0.5/ 1
3.4/	1.3/ 1	0.5/ 5	0.2/ 2	0.2/ 5	0.2/ 2	3.8/ 2	0.6/ 1	0.5/ 1										1.55/ 71

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TABLE 9

QUESTIONNAIRE/EQUIPMENT/BASE SUMMARY

Equipment	Base A	B	C	D	E	F	G	Total
AN/GPA-127	3	2	2	2	2	3	2	16
AN/FYQ-47	2	2	2	1	2	2	3	14
AN/FPS-27A	4	3	3	6	3	3	3	25
AN/GPA-124	2	2	2	1	2	1	2	12
TOTAL	11	9	9	10	9	9	10	67

76-0678-T-15

- Level and degree of spares provisioning.
- Adequacy of handbooks in terms of detail, understandability, and format.
- Amount of formal and "on-the-job" training given by Air Force to technicians for maintenance proficiency.
- Minimum skill level of personnel maintaining prime equipment.
- Type (standard or non-standard) and availability of test equipment employed.

Based on the Air Force technicians' answers to these questionnaires, deviations from the equipment's planned operational and maintenance concepts could be assessed and factors of influence identified.

4.3 $\underline{M}$ TIME REPORTS/MIL-HDBK-472 PROCEDURE III QUESTIONNAIRE

4.3.1 General

Prior to the Westinghouse field engineers' visiting the seven Air Force sites, a means to correlate the Air Force field collected data (66-1/65-110) with the prediction data was deemed necessary. The means to provide this was to have actual Air Force field maintenance technicians complete maintenance sheets depicting typical and, where possible, actual field corrective maintenance actions. In this way, the Air Force 66-1/65-110 data and the field maintenance technicians' estimates of maintenance actions could be compared. Additionally, this provided a means of comparing the field estimates and the actual equipment $\underline{M}$ predictions. In the latter case, the factors of influence which cause the field-predictive repair time difference could also be identified. Since Westinghouse used MIL-HDBK-472, Procedure II, for predicting the MTTR for the AN/FYQ-47 and the AN/GPA-127(V) systems, the $\underline{M}$ Time Reports (see figure 2) were used for collecting the Air Force field technicians estimates of repair time for these systems. As illustrated in figure 2, this time sheet provides time elements of repair similar to those of Procedure II. Thus, the quantitative difference between the prediction time elements and the actual field estimates can be derived and, where these differences are significant, the factors precipitating these differences identified.

For the AN/FPS-27A and the AN/GPA-124, Air Force field maintenance technicians completed MIL-HDBK-472, Procedure III questionnaires along with the $\underline{M}$ Time Reports. Since the $\underline{M}$ predictions for the AN/FPS-27A and

AN/GPA-124 were done in accordance with Procedure III,* the comparison between field estimates of repair times and predictive methods could be made using this Procedure III questionnaire. Additionally, the M Time Reports completed for all four systems, could be used as a baseline for identifying and analyzing the differences between the results obtained by using MIL-HDBK-472, Procedure II and Procedure III. Table 10 summarizes the type and amount of data collected from a particular site on a particular equipment.

4.3.2 Data

Tables 11 and 12 are summaries of the Air Force field maintenance technicians estimates of typical and, where possible, actual field corrective maintenance actions. As illustrated in these tables, the letters A, B, C, D, E, F, and G designate specific bases visited by Westinghouse. The numbers below these bases (1, 2, etc) indicate the number of reports/questionnaires completed at that particular site for the particular equipment. Repair times associated with each of the maintenance actions were reported via the M Time Report, or the MIL-HDBK-472, Procedure III questionnaire, or both as delineated in paragraph 4.5. As illustrated in these tables, data were collected from seven Air Force bases, (A, B, C, D, E, F, and G). As shown, 61 M Time Reports were collected on the four equipments while 57 Procedure III questionnaires were completed on the AN/FPS-27A and AN/GPA-124. Table 13 summarizes the data displayed in table 12. As shown in this table, the average repair estimate per equipment excluding preparation, item obtainment, administration, and cleanup time is

- AN/GPA-127 - 86.2 minutes.
- AN/FYQ-47 - 99.4 minutes.
- AN/FPS-27A - 94.1 minutes.
- AN/GPA-124 - 93.8 minutes.

*This includes the use of design checklists to provide scores for substitution into a regression equation whose solution results in an estimation of downtime.

TABLE 10

SITE REPORT COLLECTION SUMMARY

	Equipment	Site A	B	C	D	E	F	G	Total
M Time Reports	AN/GPA-127(V)	2	0	2	2	2	1	1	10
	AN/FYQ-47	2	2	1	2	2	1	4	14
	AN/FPS-27A	5	5	4	3	2	3	3	25
	AN/GPA-124	2	3	0	1	2	2	2	12
	TOTAL	11	20	7	8	8	7	10	61
MIL-HDBK-472 Procedure III Questionnaire	AN/GPA-127(V)	–	–	–	–	–	–	–	–
	AN/FYQ-47	–	–	–	–	–	–	–	–
	AN/FPS-27A	7	3	6	7	6	5	4	38
	AN/GPA-124	2	2	4	2	4	3	2	19
	TOTAL	9	5	10	9	10	8	6	57

76-0728-T-16

This yields an overall average field estimated repair time of 94 minutes for the sample data collected. As illustrated by these numbers, there is little difference between the four systems' average repair times as estimated by the field technicians. The closeness of these numbers may be attributed to the fact that these averages resulted from combining estimated time elements of typical examples of military electronic maintenance actions.

Table 11 summarizes the results obtained from the field technicians utilizing the Procedure III questionnaire. Nineteen sample questionnaires were collected for the AN/GPA-124 and 38 for the AN/FPS-27A. Table 14 averages the scores derived from these Procedure III questionnaires. As illustrated in these tables, per the Air Force field technicians opinion, an average corrective maintenance action performed on the AN/GPA-124 should take 100 minutes while an average corrective maintenance action on the AN/FPS-27A takes 134 minutes per Procedure III.

TABLE 11

MIL-HDBK-472 PROCEDURE III QUESTIONNAIRE SUMMARY RESULTS

	AN/GPA-124 Operating Base																			
MIL-HDBK-472, Procedure III Checklist Elements	A ①	A ②	B ①	B ②	C ①	C ②	C ③	C ④	D ①	D ②	E ①	E ②	E ③	E ④	F ①	F ②	F ③	G ①	G ②	Avg. Score
A. Checklist A-Physical Design Factors																				
(1) Access (external)	A	A	B	A	B	A	D	A	A	B	A	A	A	A	A	B	A	A	A	3.3
(2) Latches and Fasteners (ext)	C	B	C	C	C	C	C	B	B	B	C	B	B	B	C	B	C	B	C	0.9
(3) Latches and Fasteners (int)	C	B	C	B	C	C	C	B	B	B	B	A	B	A	C	B	C	B	A	1.6
(4) Access (internal)	C	A	D	A	A	B	A	D	A	A	A	A	A	A	B	B	B	A	A	3.1
(5) Packaging	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	B	B	B	1.9
(6) Units -Parts (failed)	B	B	B	B	C	A	A	B	A	A	B	B	B	B	D	B	C	A	A	2.5
(7) Visual Displays	C	C	C	B	C	C	C	A	C	C	A	C	A	C	C	B	A	B	B	1.3
(8) Fault and Operation Ind. (BITE)	B	D	B	B	B	B	B	D	B	C	A	B	C	B	B	B	D	B	D	1.7
(9) Test Points (availability)	C	C	C	B	C	B	A	C	C	D	B	C	C	C	C	A	C	B	D	2.2
(10) Test Points (identification)	C	C	C	B	B	B	C	C	B	A	C	C	B	C	A	B	C	B	A	1.4
(11) Labeling	D	D	A	A	B	A	B	D	A	A	A	B	B	A	D	A	C	B	C	2.4
(12) Adjustments	B	A	B	B	A	B	C	B	B	B	B	B	B	B	B	C	A	A	B	2.2
(13) Testing (in circuit)	A	A	A	B	A	A	A	A	A	B	A	B	B	B	A	B	B	A	A	2.5
(14) Protective Devices	B	C	A	A	A	B	A	C	C	C	A	A	A	C	B	A	C	B	A	2.3
(15) Safety (personnel)	B	B	B	A	B	B	B	A	B	B	A	A	A	A	B	B	B	A	A	2.8
Total Score for A*	24	28	26	37	32	33	28	28	36	30	43	34	38	32	26	30	24	43	40	32.2
B. Checklist B - Design Dictates - Facilities																				
(1) External Test Equipment	C	C	B	B	C	C	C	C	B	C	B	C	C	C	C	C	C	C	C	1.2
(2) Connectors	B	A	A	A	A	A	A	A	A	B	A	B	B	B	B	B	C	A	A	3.1
(3) Jigs or Fixtures	B	A	B	A	B	A	A	A	A	B	B	B	B	B	B	A	B	A	B	2.8
(4) Visual Contact	A	A	A	A	C	C	A	A	A	A	A	A	A	A	B	A	A	A	A	3.6
(5) Assistance (Op Pers)	B	B	B	A	A	B	B	A	A	A	B	B	B	B	C	A	B	A	B	2.6
(6) Assistance (Tech Pers)	B	A	B	A	B	B	B	B	B	B	A	A	A	A	A	B	A	B	B	2.8
(7) Assistance (Superv)	A	B	B	A	B	B	B	B	B	A	B	B	B	B	B	B	A	B	C	2.3
Total Score for B*	17	21	18	26	15	17	19	21	22	19	20	17	17	17	13	19	17	21	15	18.5
C. Checklist C - Design Details - Maintenance Skills																				
(1) Arm, Leg and Back Strength	4	3	3	4	4	4	4	2	2	2	4	4	4	4	3	2	2	2	3	3.2
(2) Endurance and Energy	4	1	4	4	4	3	3	2	2	2	4	4	4	4	2	1	1	2	2	2.8
(3) Eye-Hand Coord, etc.	0	0	3	4	0	1	0	0	1	1	0	0	2	0	4	1	1	2	1	1.1
(4) Visual Acuity	1	0	3	4	0	0	0	0	1	1	2	2	1	1	4	2	2	1	2	1.4
(5) Logical Analysis	0	1	2	2	0	0	1	1	1	0	0	0	0	1	4	2	0	0	3	0.9
(6) Memory-Things and Ideas	2	1	2	2	2	2	1	1	1	1	0	1	0	1	3	2	1	1	3	1.4
(7) Planfulness and Resourcefulness	1	1	3	3	1	1	1	1	1	1	1	1	1	1	1	2	1	2	3	1.4
(8) Alertness, Caution and Accuracy	0	0	2	2	0	0	0	1	1	2	1	1	1	1	4	1	0	1	3	1.1
(9) Concentration, etc.	1	0	3	2	1	0	0	0	1	1	2	1	1	1	4	1	0	0	3	1.2
(10) Initiative and Incisiveness	1	0	4	2	1	1	2	1	1	2	1	1	1	1	3	1	2	1	3	1.5
Total Score for C*	14	7	29	29	13	12	12	9	12	13	15	15	15	15	32	15	10	12	26	16.1

*Checklists A and B offer multiple choice qualitative answers each of which is associated with a numerical score.
Checklist C answers are directly numerical.

AN/FPS-27A
Operating Base

Avg. Score	A							B			C						D							E						F					G				Avg. Score
	1	2	3	4	5	6	7	1	2	3	1	2	3	4	5	6	1	2	3	4	5	6	7	1	2	3	4	5	6	1	2	3	4	5	1	2	3	4	
3.3	D	A	A	A	A	A	A	B	B	A	A	A	A	A	A	B	A	A	A	A	A	A	A	A	A	A	A	A	B	A	B	A	A	A	A	A	A	A	3.6
0.9	B	A	B	B	A	B	A	A	A	B	B	B	A	A	A	B	A	A	A	A	A	A	A	B	A	A	A	B	A	C	B	A	B	A	A	A	B	B	3.2
1.6	B	A	B	B	C	B	A	B	B	B	B	B	B	A	A	B	B	B	A	B	A	B	A	C	A	B	A	A	C	C	B	A	B	A	B	B	B	B	2.4
3.1	D	A	A	A	D	A	A	A	D	B	A	A	B	A	A	B	A	A	A	A	A	A	A	B	A	A	A	A	A	A	A	A	B	A	A	A	A	D	3.3
1.9	B	B	B	B	B	B	C	B	C	B	B	C	C	C	B	B	B	C	C	C	B	B	B	B	B	B	B	B	B	C	B	A	C	C	A	B	B	B	1.5
2.5	D	D	B	A	A	B	A	B	D	B	A	D	D	B	B	C	C	C	D	D	D	B	B	D	B	B	B	B	B	D	C	B	D	B	B	B	B	B	1.6
1.3	A	B	A	A	B	B	B	A	C	A	C	A	A	C	B	B	C	C	B	C	B	B	B	A	B	A	B	C	A	B	C	C	C	C	C	C	B	C	1.8
1.7	C	B	B	D	D	B	D	A	B	B	A	B	C	B	A	B	B	B	B	B	A	A	A	B	A	B	B	A	B	B	D	B	A	B	B	A	A	B	2.4
2.2	C	C	B	B	C	C	B	B	C	C	C	C	C	C	C	C	C	C	C	C	C	B	B	C	C	C	B	B	B	C	D	C	D	C	C	C	C	D	2.1
1.4	C	B	B	B	B	B	B	B	A	A	B	B	A	C	B	B	B	C	B	B	B	B	A	B	B	B	C	B	B	B	A	A	B	A	A	C	A	B	2.2
2.4	D	B	A	B	D	B	A	A	D	B	D	B	D	B	B	B	A	A	B	C	D	A	A	B	B	A	A	B	B	A	D	A	D	A	A	A	B	B	2.4
2.2	B	B	B	B	B	C	B	A	C	C	C	B	C	C	B	C	C	C	B	C	B	C	B	C	B	A	B	A	B	B	C	C	B	B	C	B	B	C	1.3
2.5	A	B	B	B	A	A	B	B	B	B	B	A	B	B	B	B	B	B	A	B	A	B	B	B	A	A	B	A	B	B	B	A	B	B	A	B	A	B	1.3
2.3	C	B	A	B	A	A	C	B	C	B	A	B	A	A	C	A	A	B	A	A	A	A	A	B	A	A	A	B	A	A	C	A	A	A	A	B	A	B	2.9
2.8	B	B	B	B	A	A	B	A	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	A	A	B	B	B	B	B	B	B	A	2.3
32.2	22	34	39	35	34	38	35	43	18	32	32	34	30	30	36	28	34	28	38	28	42	39	45	26	44	46	39	41	35	30	20	44	24	38	42	34	42	24	34.3
1.2	C	C	C	C	C	C	C	C	C	C	B	C	C	C	B	C	C	C	C	D	B	C	C	C	C	C	C	C	C	C	D	C	C	C	C	C	C	C	1.0
3.1	B	C	B	A	B	B	B	B	C	B	C	C	B	C	B	B	C	C	B	B	A	B	B	C	A	B	B	A	C	B	C	B	B	C	B	B	B	C	1.6
2.8	B	B	B	C	B	B	B	B	B	B	C	C	B	C	C	B	C	C	C	C	B	B	B	B	B	B	B	C	C	B	C	C	B	C	C	B	B	C	1.2
3.6	B	B	A	B	A	B	A	A	C	B	C	B	A	A	B	B	C	B	A	A	A	A	A	C	A	C	C	C	C	A	B	B	B	A	A	A	A	B	2.5
2.6	B	B	A	B	B	B	A	B	B	B	B	B	A	A	A	B	A	A	B	B	B	A	B	B	B	A	B	B	A	B	B	B	B	B	B	B	B	B	2.5
2.8	A	B	B	A	B	B	A	A	C	B	C	B	B	B	B	B	B	B	A	B	B	A	C	C	B	B	B	B	B	B	B	B	B	B	B	B	B	B	2.1
2.3	A	B	B	B	B	A	B	B	B	B	C	B	B	B	B	B	B	B	B	B	B	A	B	B	B	B	A	A	A	B	B	B	B	B	B	B	B	B	2.3
18.5	17	11	17	15	15	15	19	17	7	13	4	9	17	13	14	13	9	11	15	12	18	21	13	7	17	13	13	13	11	15	8	11	13	11	13	15	15	9	13.1
3.2	4	3	3	3	4	3	2	4	0	4	2	1	0	2	0	2	2	2	3	2	2	1	1	3	2	4	4	2	4	3	2	1	1	2	3	4	2	4	2.4
2.8	3	3	3	3	4	4	1	3	2	4	2	2	2	2	0	2	1	2	3	2	2	3	1	3	2	4	4	2	4	3	3	2	1	2	2	3	2	4	2.5
1.1	0	1	2	3	0	2	0	1	0	2	1	2	0	2	0	1	1	1	2	0	2	0	1	2	1	2	2	0	2	0	1	0	0	0	2	2	1	2	1.1
1.4	0	0	2	1	0	0	0	0	3	2	2	2	2	2	0	2	2	1	2	0	2	0	1	2	2	2	2	0	2	0	0	0	2	2	2	1	1	2	1.2
0.9	0	2	1	3	1	0	0	1	0	1	0	1	2	1	0	0	2	1	2	0	1	0	0	2	1	2	2	1	2	0	2	2	1	0	1	1	1	1	1.0
1.4	2	2	2	1	2	1	0	0	1	2	2	2	2	2	0	1	2	2	2	0	1	0	0	2	2	2	2	2	2	1	2	2	0	1	2	1	2	1	1.4
1.4	2	2	2	2	4	2	1	4	2	3	2	2	1	2	0	1	2	1	1	0	2	2	1	1	2	2	2	2	3	2	2	2	0	2	2	1	2	2	1.8
1.1	0	1	1	1	2	0	1	0	0	2	1	0	0	0	0	1	0	2	0	0	1	0	0	0	0	2	1	0	2	0	0	0	0	0	2	1	0	1	0.6
1.2	0	1	2	2	3	2	0	0	0	2	1	1	2	1	0	1	1	2	1	0	1	0	0	1	1	2	1	2	2	2	0	1	0	0	0	1	0	2	1.0
1.5	2	2	3	2	3	2	1	2	0	2	2	2	2	0	0	1	2	2	1	0	2	2	0	2	2	2	1	2	3	2	2	2	0	1	0	1	0	2	1.5
16.1	13	17	21	21	23	16	6	15	8	24	15	15	13	14	0	12	15	16	17	4	16	8	5	18	15	24	21	13	26	13	14	12	5	10	16	16	11	21	14.4

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TABLE 12.

MAINTAINABILITY TIME REPORT SUMMARY

		Times Per Base Per Equipment							
		T_P	T_D	T_I	T_C	T_S	T_{CO}	T_{CU}	T_T
AN/GPA-127(V)	A1	25	45	2 Dy	165	60	30	20	240
	2	20	15	5	5	5	-	5	20
	C1	10	37	15	45	15	10	15	92
	2	10	30	15	5	10	10	10	45
	D1	5	37	15	90	17	10	5	137
	2	15	30	10	30	5	5	5	65
	E1	5	40	15	3	5	-	10	43
	2	5	65	20	5	5	-	10	70
	F1	10	20	5	5	30	5	5	30
	G1	15	60	15	60	10	-	15	120
Average		12	37.9	-	41.3		7	10	86.2
AN/FYQ-47	A1	5	25	3	10	10	5	5	40
	2	15	45	30	30	15	10	10	85
	B1	10	15	1 Wk	60	1 Wk	5	5	80
	2	10	30	1 Wk	45	12	15	20	90
	C1	5	30	5	10	5	10	5	50
	D1	7	80	4	75	10	5	5	160
	2	7	95	4	100	15	10	10	205
	E1	10	20	5	15	10	5	10	40
	2	10	20	5	15	10	5	10	40
	F1	7	15	15	60	3	5	15	80
	G1	5	38	5	5	10	20	20	63
	2	7	90	1.5 Dy	90	150	15	7	192
	3	7	45	4 Dy	90	10	20	5	155
	4	17	67	35	30	40	15	10	112
Average		8.7	43.9	-	45.4	-	10.1	9.8	99.4
AN/FPS-27A	A1	22	62	16	38	55	17	15	117
	2	5	15	60	20	60	15	15	50
	3	10	30	10	60	15	-	10	90
	4	5	15	5	15	30	5	5	35
	5	10	90	5	30	15	-	10	120

Table 12. (Continued)

		Times Per Base Per Equipment							
		T_P	T_D	T_I	T_C	T_S	T_{CO}	T_{CU}	T_T
AN/FPS-27A (Continued)	B1	21	67	5	35	11	2	5	104
	2	8	43	6	15	12	15	15	73
	3	15	56	5	-	40	5	5	61
	4	25	45	5	20	15	15	10	80
	5	9	70	10	-	20	15	5	85
	C1	15	60	15	45	22	15	15	120
	2	15	15	5	20	15	-	5	35
	3	15	38	-	75	-	90	38	203
	4	10	45	8	30	10	30	10	105
	D1	15	45	10	35	15	17	7	97
	2	7	22	10	20	15	7	7	49
	3	15	45	10	60	10	10	10	115
	E1	10	15	5	10	15	2	5	27
	2	8	70	5	30	15	10	10	110
	F1	2	10	10	2	15	2	5	14
	2	10	127	10	105	17	52	30	284
	3	10	28	12	60	30	-	5	88
	G1	12	60	7	60	20	60	-	180
	2	8	30	5	34	30	-	10	64
	3	8	15	3	27	4	5	5	47
Average		11.6	44.7	-	33.8	-	15.6	10.3	94.1
AN/GPA-124	A1	8	45	3	10	10	7	5	62
	2	15	60	15	20	15	10	10	90
	B1	8	60	1.5 Dy	50	12	-	12	110
	2	10	90	8 Dy	10	15	2	7	102
	3	2	25	7 Dy	90	6 Dy	-	5	115
	D1	5	102	10	20	10	30	5	152
	E1	10	20	5	15	10	5	10	40
	2	10	20	5	15	10	5	10	40
	F1	8	80	7 Dy	40	150	30	20	150
	2	10	90	-	-	45	30	20	120
	G1	7	57	4 Dy	15	12	8	5	80
	2	5	45	5	5	-	15	20	65
Average		8.2	57.8	-	24.2	-	11.8	10.8	93.8

Table 12. (Continued)

	Times Per Base Per Equipment							
	T_P	T_D	T_I	T_C	T_S	T_{CO}	T_{CU}	T_T
Overall Equipments' Average Times	11.6	44.7	-	33.8	-	15.6	10.3	94.1

where:

T_P - Preparation time

T_D - Fault location/verification time

T_I - Item obtainment time

T_C - Fault correction/adjustment time

T_S - Administrative time

T_{CO} - Checkout time

T_{CU} - Cleanup time

T_T - Total time excluding T_P, T_I, T_S and T_{CU}

TABLE 13

COMPOSITE MAINTAINABILITY TIME REPORT DATA SUMMARY

TIMES – MINUTES

EQUIPMENT	NO. OF SAMPLES	T_D (FAULT LOCATION/ VERIFICATION)	T_C (FAULT CORRECTION/ ADJUSTMENT)	CHECKOUT TIME	TOTAL TIME*
AN/GPA-127	10	37.9	41.3	7.0	86.2
AN/FYQ-47	14	43.9	45.4	10.0	99.4
AN/FPS-27A	25	44.7	33.8	15.6	94.1
AN/GPA-124	12	57.8	24.2	11.8	93.8

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* Does not include T_P (Preparation), T_I (Item Obtainment), T_S (Administrative), and Cleanup

TABLE 14

MIL-HDBK PROCEDURE III QUESTIONNAIRE RESULT SUMMARY

ELEMENT	**Average Scores** (as calculated from Table 11) AN/GPA-124 (19 Data Samples)	AN/FPS-27A (38 Data Samples)	OVERALL AVERAGE
Checklist A Score	32.2	34.3	33.6
Checklist B Score	18.5	13.1	14.9
Checklist C Score	16.1	14.4	15
Mean Predicted Downtime (as calculated per MIL-HDBK-472, Procedure III)	100 minutes	134 minutes	121 minutes

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4.4 $\underline{M}$ DEMONSTRATION TEST DATA

4.4.1 General

$\underline{M}$ demonstration tests were conducted on two of the four systems under study. These tests were conducted in accordance with MIL-STD-471 and provide data depicting equipment failures which reflect, in theory, typical M_{ct}'s. These data were utilized in this study to illustrate that the recommended equipment maintenance concept was a viable concept especially in terms of technician training required and inherent equipment design and that the $\underline{M}$ prediction made on the equipment could be achieved. Additionally, the demonstration data provided an insight on some potential "Operational Influences on Maintainability". These influences, along with the actual test data and the conditions under which the tests were conducted on the AN/FPS-27A modification kit and AN/FYQ-47, are presented in the following two paragraphs.

4.4.2 AN/FPS-27A $\underline{M}$ Demonstration Test

A $\underline{M}$ Demonstration Test was conducted on the AN/FPS-27A. This test was conducted in accordance with MIL-STD-471, Test Method 2, using a sample of 50 simulated faults. It was the intent of this test to demonstrate that the ($\bar{M}_{ct}$) for the AN/FPS-27A was not greater than 30 minutes and the maximum M_{ct} at the 95th percentile was not greater than 90 minutes.

In some cases, $\underline{M}$ demonstration tests are conducted at the contractor's plant. However, since the AN/FPS-27A Mod Kit equipment must interface with an existing system, an isolated test without live radar data and without a Monitor Console (located at each site) would be of limited value in determining system capability in the field. Thus, the test was conducted at the North Charleston AFS, Charleston, South Carolina.

The basic conditions of the tests are outlined in table 15. Table 16 shows the data collected for each usable task. Tasks 7 and 20 were deleted and rerun as tasks 55 and 59. Task 41 was deleted completely. The reasons for this were the following:

- Incorrect/misleading failure symptoms described to maintenance team.
- During troubleshooting, technicians removed an LRU and failed to replace it after determining it wasn't at fault. This oversight made further troubleshooting extremely difficult. The task was then considered non-representative.
- No system symptom occurred after insertion of a fault. This fault would normally be detected only when attempting a preventive maintenance/adjustment to the LRU.

Tasks 30, 33, and 43 were abandoned after 90 minutes because the team could not correct the fault. The results of rerun by a different team are shown in tasks 31, 34, and 44. Tasks 56, 57, and 58 were not needed to make up 40 useable tasks.

TABLE 15

AN/FPS-27A MOD KIT M DEMONSTRATION TEST CONDITIONS

Place:	AN/FPS-27 Site 792nd Radar Squadron North Charleston AFB, Charleston, South Carolina
Personnel:	2-man teams. 6 U.S. Air Force (USAF) and 2 Royal Canadian Air Force (RCAF)
Background:	Test personnel normally assigned to perform maintenance on premod receiver.
Test Teams:	2-man teams.
Test Conduct:	2 shifts per day, 2 teams per shift. Team members rotated on a daily basis.
Data Recording:	Westinghouse data recorder used diary-type forms to record maintenance task activities.
Data Verification:	Procuring Activity Test Direction verifies data collected for each task by signing data recording form.
Tasks Available:	A list of 100 tasks were prepared each of which could be inserted into the equipment.
Task Selection:	Random selection made on a shift basis from list of 100 tasks.

TABLE 16

AN/FPS-27A DEMONSTRATION TEST DATA

Task No.	Name	Active Down Time (minutes)*				
		$\overline{T}_p$	$\overline{T}_d$	$\overline{T}_i$	$\overline{T}_c$	Total
1	VGA	1.0	6.5	-	19.0	26.5
2	Arith/CFAR	3.0	36.5	-	.5	40.0
3	RF Power Supply	3.0	3.0	-	46.5	52.5
4	SLB/Nor Logic	4.5	15.5	1.0	.5	21.5
5	VGA	1.5	10.5	0.5	8.0	20.5
6	A/D Converter	2.0	9.0	-	3.0	14.0
7	delete, use #55					
8	VGA	3.5	12.5	-	14.5	30.5
9	Logic Channel BD	5.5	35.0	-	10.5	51.0
10	A/D Converter	2.5	45.0	1.0	0.5	49.0
11	VGA	2.5	6.0	0.5	8.5	17.5
12	Channel BD	3.0	4.5	-	9.0	16.5
13	VGA	2.0	2.5	0.5	2.0	7.0
14	Relay Board	4.5	7.0	-	.5	12.0
15	Arith/CFAR	2.0	33.0	-	.5	35.5
16	Mixer Amplifier	0.5	12.5	-	6.0	19.0
17	VGA	-	4.5	-	8.5	13.0
18	Memory Bd	0.5	15.5	-	2.0	18.0
19	A/D	2.0	5.5	-	-	7.5
20	delete, use #59					
21	Arith/CFAR	1.5	48.5	1.5	-	51.5
22	Sunstrobe Receiver	2.5	15.0	.5	5.0	23.0
23	Log Channel BD	1.0	9.5	.5	8.5	19.5
24	IF Power Supply	3.0	9.0	-	49.0	61.0
25	Arith/CFAR	1.5	24.0	1.0	0.5	27.0
26	Log Channel BD	2.0	7.5	-	9.5	19.0
27	A/D Converter	1.0	5.5	-	-	6.5
28	CFAR Channel BD	-	3.5	1.5	7.5	12.5
29	VGA	0.5	12.5	-	2.0	15.0
30	abandon, use #31					
31	Integrator	4.5	40.0	.5	1.0	46.0
32	Log Channel BD	1.0	8.0	.5	6.0	15.5
33	abandon, use #34					
34	185 mc Amplifier	5.0	85.0	-	-	90
35	SLB/Normal	-	9.5	-	22.5	32.0
36	SLB/Normal	-	16.0	-	1.5	17.5
37	VGA	2.0	5.5	-	6.0	13.5

The following summarizes the AN/FPS-27A demonstration data illustrated in table 16.

For the 50 usable tasks:

- $\overline{T}_p$ = 1.64 minutes.
- $\overline{T}_d$ = 17.93 minutes.
- $\overline{T}_i$ = 0.35 minute.
- $\overline{T}_c$ = 6.18 minutes.
- $\overline{T}$ = 26.01 minutes.
- $\overline{M}_{ct}$ (80 percent confidence) = 27.98 minutes.
- $\overline{M}_{max_{ct}}$ (95th percentile) = 58.8 minutes.

4.4.3 AN/FYQ-47 $\underline{M}$ Demonstration Test

A $\underline{M}$ Demonstration Test was conducted on the AN/FYQ-47 in accordance with MIL-STD-471, Test Method 1 at the contractor's plant on 14 March 1968. It was the intent of this test to demonstrate that the $\overline{M}_{ct}$ both "on-line" and "off-line" for the common digitizer does not exceed 30 minutes. Fifty-one tasks were performed to demonstrate the "on-line" MTTR. Table 17 summarizes each task and the time taken for each of these corrective maintenance actions. The "off-line" demonstration data was not included in this report since the 66-1/65-110 data base used in this study only reflects downtimes associated with "on-line" type of corrective maintenance. Table 18 summarizes the results and other pertinent data of the test as presented in the contractor's test report. As illustrated in table 17, 7 of the 51 maintenance actions exceeded 30 minutes. One of the planned tasks was deleted since the fault could not be inserted into the particular board. In test No. 41 the initial fault was isolated and a spare board inserted. However, the spare board was initially defective and the task took an additional 2 minutes and 53 seconds to restore the system.

TABLE 17

AN/FYQ-47 MAINTAINABILITY DEMONSTRATION TEST DATA

Test No.	Task No.	Location/Item	TIME (HOURS – MINUTES – SECONDS) Isolation	Repair	Confidence	Total	Remarks	Action
30	1	CMP (Group 4) CDBB8 (RQG)	1.15	5.80	10 sec	6.33	No alarms. No video crossover. Using video in Sector 1.	Replaced 6 cards
31	236	Inv.QB6/TPG (Gp 10,11,12,16, BAJFO,TRG 3 & 11 OBG)	5.06	5.37	24 sec	11.07	Beacon to Radar Message Alarms	Replaced 7 cards
32	347	Cmp ARTG/TTG (Grp 10,11) CBDJ2	5.05	3.41	10 sec	8.56	No comment	Replaced 2 cards
33	138	DAS (Group 2) DADA6 (HPG)	1.15	12.50	10 sec	13.20	RHI reports unable to get maximum range.	Replaced 17 cards
34	417	SRC (Group 8) BBDF4 (MCG)	1.30	3.15	10 sec	4.55	No height finder or gap filler message.	Replaced 5 cards
35	421	SYN BRG (Gp.6) BABD8	45 sec	3.50	10 sec	4.00	Computer center notifies that it is receiving garbled data due to No-Starter message signal, Channel 3.	Replaced 3 cards
36	136	DC2 (Group 2) DABA4 (HPG)	20 sec	3.90	10 sec	4.20	Unable to obtain height maximum on HI shelf.	Replaced 4 cards
37	337	F21 (Gp 2 & 3) CBBEO (ARTG)	19.25	31.00	10 sec	50.35	Chose wrong group (TDG Group 14); rectified with correct group. Omitted one card (the bugged card). Had to recheck group and found omission.	Replaced 26 cards
38	211	(G21) (Gp19 OBG) G.P.5,6,12,13 TPG BAFF4 (OBG-TPG)	22.00	3.10	10 sec	25.20	Numerous alarms	Replaced 15 cards
39	4	(AQ) (GP1) (CDBD1) (RQG)	4.20	4.16	10 sec	8.46	Many secondary alarms	Replaced 7 cards
40	292	(BU) (Gp 1,3,4,5, 6,9,12,15) (CCBBO (TDG/MO6)	2.05	2.16	10 sec	4.31	Computer center reports ACE not eliminating clutter.	Replaced 3 cards
41	46	(LPD) (Gp.8) DABJ8 (HPG)	16.53	1.38	10 sec	18.41 Note: Defective spare isolation 2.53	RHI operator reports constant parity error Removed one of two suspected groups. Fault remained. Removed other group. Rectified fault.	Replaced 21 cards
42	385	VR (Group 1) BBHJ8 (MC6/MEM)	5.15	6.35	10 sec	12.00	Target process alarms. Erratic target output. Procedure for discrete card replacement is Power Off.	Replaced 6 cards
43	429	Height Shelf Switch	8.05	2.10	10 sec	10.25	RHI operator cannot move height line with trackball; switches to Group 1 shelf to verify counters, switches and logic work correctly. Finds error is in the Group II trackball deflection.	Replaced switch
44	414	(CMP) (Gp9) BBBD8 (MCG)	3.05	8.11	10 sec	10.26	No comment.	Replaced 6 cards
45	316	CTR (Gp 10) CBFJ2 (ARTG)	2.00	5.38	10 sec	7.48	No comment	Replaced 8 cards

31	236	Inv.QB6/TPG (Gp 10,11,12,16, BAJFO,TRG 3 & 11 OBG)	5.06	5.37	24 sec	11.07	Beacon to Radar Message Alarms	Replaced 7 cards
32	347	Cmp ARTG/TTG (Grp 10,11) CBDJ2	5.05	3.41	10 sec	8.56	No comment	Replaced 2 cards
33	138	DAS (Group 2) DADA6 (HPG)	1.15	12.50	10 sec	13.20	RHI reports unable to get maximum range.	Replaced 17 cards
34	417	SRC (Group 8) BBDF4 (MCG)	1.30	3.15	10 sec	4.55	No height finder or gap filler message.	Replaced 5 cards
35	421	SYN BRG (Gp.6) BABD8	45 sec	3.50	10 sec	4.00	Computer center notifies that it is receiving garbled data due to No-Starter message signal Channel 3.	Replaced 3 cards
36	136	DC2 (Group 2) DABA4 (HPG)	20 sec	3.90	10 sec	4.20	Unable to obtain height maximum on HI shelf.	Replaced 4 cards
37	337	F21 (Gp 2 & 3) CBBEO (ARTG)	19.25	31.00	10 sec	50.35	Chose wrong group (TDG Group 14); rectified with correct group. Omitted one card (the bugged card). Had to recheck group and found omission.	Replaced 26 cards
38	211	(G21) (Gp19 OBG) G.P.5,6,12,13 TPG BAFF4 (OBG-TPG)	22.00	3.10	10 sec	25.20	Numerous alarms	Replaced 15 cards
39	4	(AQ) (GP1) (CDBD1) (RQG)	4.20	4.16	10 sec	8.46	Many secondary alarms	Replaced 7 cards
40	292	(BU) (Gp 1,3,4,5, 6,9,12,15) (CCBBO (TDG/ MO6)	2.05	2.16	10 sec	4.31	Computer center reports ACE not eliminating clutter.	Replaced 3 cards
41	46	(LPD) (Gp.8) DABJ8 (HPG)	16.53	1.38	10 sec	18.41 Note: Defective spare isolation 2.53	RHI operator reports constant parity error Removed one of two suspected groups. Fault remained. Removed other group. Rectified fault.	Replaced 21 cards
42	385	VR (Group 1) BBHJ8 (MC6/ MEM)	5.15	6.35	10 sec	12.00	Target process alarms. Erratic target output. Procedure for discrete card replacement is Power Off.	Replaced 6 cards
43	429	Height Shelf Switch	8.05	2.10	10 sec	10.25	RHI operator cannot move height line with trackball; switches to Group 1 shelf to verify counters, switches and logic work correctly. Finds error is in the Group II trackball deflection.	Replaced switch
44	414	(CMP) (Gp9) BBBD8 (MCG)	3.05	8.11	10 sec	10.26	No comment.	Replaced 6 cards
45	316	CTR (Gp 10) CBFJ2 (ARTG)	2.00	5.38	10 sec	7.48	No comment	Replaced 8 cards
46	328	RD2 (Gp 6,9) CBFC4 (ARFG)	5.40	1.58	10 sec	7.48	Technician went directly to "Driver Cards" as he noted bit "8" hung up. Drawings indicated exact board.	Replaced 1 card
47	21	REG (Gp 10,11,9) CABH8 (BRG)	4.45	5.44	10 sec	10.39	No comment	Replaced 7 cards
48	399	C27 (Gp 14) BBDC6 (MCG)	45.21	10 sec	10 sec	45.41	Target Processing Alarm. Removed digit board. Did not correct error. Corrected error with second card replacement group.	Replaced 10 cards
49	432	S20 Switch	4.15	28.30	10 sec	32.55	No comment.	Replaced switch
50	441	+5V Power Supply	18.00	10.24	10 sec	28.34	Trouble shooting power supply; must have list of voltages and test readings for normal.	Replaced transistor
51	396	CCS (Gp.2) BBHA7 (MCG)	9.15	8.40	10 sec	18.05	No comment.	Replaced 6 cards

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Test No.	Task No.	Location/Item	TIME (HOURS – MINUTES – SECONDS) Isolation	Repair	Confidence	Total	Remarks	Action
1	78	GBI (Group 3) DABF2 (HPG)	2.30	3.20	10 sec	6.00	No comment	Replaced 8 cards
2	11	SRS (Group 4) CABD4 (BRG)	44.50		10 sec	45.00	BRG fault;could be isolated primarily to one of three groups: (1) TDG, (2) BRG, (3) ARTG. Incorrect group (TDG) was first selection	Replaced 26 cards
3	129	GAI (Group 5 & 4) (HF 4) DADG6 (HPG)					Fault isolated and corrected; secondary fault occurred due to height operator misadjusting cable connector.	Replaced 15 cards
4	167	C27 (Group 17) BAFD 2 (OBG-TPL)	5.10	7.00	10 sec	12.20	Memory problem, numerous secondary alarms.	Replaced 12 cards
5	252	F21 (Group 3, 9,11) BAHF2 (TBG)	5.20	3.20	10 sec	8.50	Constant "Inprocess Full Alarm" secondary detector alarms.	Replaced 8 cards
6	29	F21 (Group 9) CABG2 (BRG)	12.30	3.22	15 sec	16.07	Beacon Message alarm	Replaced 5 cards
7	375	DIG (Group 3) BBFDI (MCG)	2.55	3.55	10 sec	7.00	Bit hung up	Replaced 5 cards
8	302	C27 (Group 4) CCDJ2 (TPG)	8.45	7.50	10 sec	16.45	Message alarm. No PPI output	
9B	156	(BN) (Group 2, 3,4,9,10) BAH18 (TPG)	Not Demonstratable				No comment	Replaced 10 cards
10	199	GAI (Group 16 &13) TPS12 or 13 or 6 BAFF2 (OBG)	42.45	7.00	10 sec	49.55	Output service alarm, inprocess full alarm. Replace incorrect group (OBG Group 9).	Replaced 26 cards
11	393	F21 (Group 6) BBDF8(MCG–MCM	1.40	3.10	10 sec	5.00	Computer center reports no status message	Replaced 4 cards
12	274	INV.(Group 6&11) CCBCO (TDG)	1.40	3.20	10 sec	5.10	No comment	Replaced 4 cards
13	142	RD3 (Group8) BADJ3 (IBG)	2.15	7.58	15 sec	10.28	Military data out of Channel 1 Route 2. Could isolate correct driver card is permitted to use functions. Replacement would then only be one card.	Replaced 14 cards
14	33	CUD (Group 2) DABC6 (HPG)	1.00	3.12	10.sec	4.22	No comment	Replaced 3 cards
15	286	F21 (Group 6 or 14) CCFED (TDG)					No map messages reported from computer center	Replaced 5 cards
16	427	DRG (Group 1) BAB14 (HDS)	30 sec	2.00	10 sec	2.40	No comment	Replaced 3 cards
17	440	A6/Q1-20V EU/Power Supply	24.30	14.50	10 sec	39.30	Procedure required for power supply tasks Must be included in maintenance manuals	Replaced transistor
18	369	BU (GR.11,12) BBD10 (MCG)	13.40	4.00	10 sec	17.50	Sensitive and Normal detector alarms. Fault could be isolated to two groups. TDG or MCG. TDG (Group 2) replaced first	Replaced 14 cards
19	110	(F21) (Grp 2 & 6) DADB8 (HPG)	7.45	5.37	10 sec	13.32	Task picked for HF1 but not hooked up so ran task on similar shelf HF0: Height operator reports no right limit on azimuth vernier	Replaced 17 cards
20	318	BU (Group 3) CBBB4 (ARTG)	16.45	8.35	10 sec	25.30	Fault isolated to two groups, RTQ and ARTG. RTQ removed and replaced. Fault not rectified. Replaced other group. Fault corrected.	Replaced 14 cards
21	65 75	Inv (Grp 4&6 Az) DADE8 (HPG)	1.15	8.5	50 sec	10.10	No comment	Replaced 10 cards
22	444	A3Q1	24.45	98.15	10 sec	123.00	Fault indicators confusing, power up procedure required, faulty power supply in tester. Tester power supply not approved and accepted from vendor.	Replaced transistors

6	29	F21 (Group 9) CABG2 (BRG)	12.30	3.22	15 sec	16.07	Beacon Message alarm	Replaced 5 cards
7	375	DIG (Group 3) BBFDI (MCG)	2.55	3.55	10 sec	7.00	Bit hung up	Replaced 5 cards
8	302	C27 (Group 4) CCDJ2 (TPG)	8.45	7.50	10 sec	16.45	Message alarm. No PPI output	
9B	156	(BN) (Group 2, 3,4,9,10) BAH18 (TPG)		Not Demonstratable			No comment	Replaced 10 cards
10	199	GAI (Group 16 &13) TPS12 or 13 or 6 BAFF2 (OBG)	42.45	7.00	10 sec	49.55	Output service alarm, inprocess full alarm. Replace incorrect group (OBG Group 9).	Replaced 26 cards
11	393	F21 (Group 6) BBDF8(MCG–MCM)	1.40	3.10	10 sec	5.00	Computer center reports no status message	Replaced 4 cards
12	274	INV (Group 6&11) CCBCO (TDG)	1.40	3.20	10 sec	5.10	No comment	Replaced 4 cards
13	142	RD3 (Group8) BADJ3 ()BG)	2.15	7.58	15 sec	10.28	Military data out of Channel 1 Route 2. Could isolate correct driver card is permitted to use functions. Replacement would then only be one card.	Replaced 14 cards
14	33	CUD (Group 2) DABC6 (HPG)	1.00	3.12	10 sec	4.22	No comment	Replaced 3 cards
15	286	F21 (Group 6 or 14) CCFED (TDG)					No map messages reported from computer center	Replaced 5 cards
16	427	DRG (Group 1) BAB14 (HDS)	30 sec	2.00	10 sec	2.40	No comment	Replaced 3 cards
17	440	A6/Q1-20V EU/Power Supply	24.30	14.50	10 sec	39.30	Procedure required for power supply tasks Must be included in maintenance manuals	Replaced transistor
18	369	BU (GR.11,12) BBD10 (MCG)	13.40	4.00	10 sec	17.50	Sensitive and Normal detector alarms. Fault could be isolated to two groups. TDG or MCG. TDG (Group 2) replaced first	Replaced 14 cards
19	110	(F21) (Grp 2 & 6) DADB8 (HPG)	7.45	5.37	10 sec	13.32	Task picked for HF1 but not hooked up so ran task on similar shelf HF0: Height operator reports no right limit on azimuth vernier	Replaced 17 cards
20	318	BU (Group 3) CBBB4 (ARTG)	16.45	8.35	10 sec	25.30	Fault isolated to two groups, RTQ and ARTG. RTQ removed and replaced. Fault not rectified. Replaced other group. Fault corrected.	Replaced 14 cards
21	65 75	Inv (Grp 4&6 Az) DADE8 (HPG)	1.15	8.5	50 sec	10.10	No comment	Replaced 10 cards
22	444	A3Q1	24.45	98.15	10 sec	123.00	Fault indicators confusing, power up procedure required, faulty power supply in tester. Tester power supply not approved and accepted from vendor.	Replaced transistors
23	258	SRC (Grp 5&6) CCDE2 (TDG-MOS)	9.20	7.20	10 sec	16.50	No comment	Replaced 10 cards
24	94	SRL (Group 1) DABBO (HPG)	4.35	3.23	30 sec	8.28	No height range report in height finder reply message.	Replaced 5 cards
25	359	G21 (Gp 5,9,10,11) CBDJ8 (ARTG)	1.00	10.00	12 sec	11.12	Notification from center. No beacon data	Replaced 15 cards
26	333	RD (Gp 5&2,11&12) CBFB5 (ARTG)	2.10	7.10	10 sec	9.30	Notification from center. No. P_1 and P_3 external pulses. No beacon "Driver Card"	Replaced 13 cards
27	390	XYS (Grp 2,4) BBHG3 (MCG)					Target process alarm. No data outputs	Replaced 14 cards
28	134 135	Eq (Gp.5) DADJO (HPG)	15.00	6.25	10 sec	21.35	Antenna cannot be positioned correctly. Coordinate converter replaced.	Replaced 15 cards
29	350	Ro (Group 5,11) CBFG3 (ARTG)	3.00	7.20	10 sec	10.30	No beacon test targets.	Replaced 9 cards

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TABLE 18

AN/FYQ-47 ON-LINE MAINTAINABILITY DEMONSTRATION TEST DATA SUMMARY

Demonstrated MTTR = 17:47 Minutes	
Percent of tasks accomplished in under 2 hours = 98%	
Number of tasks exceeding 8-hour limitation = 8	
Test Team: Two-man Teams	
Test Personnel:	Two U.S. Air Force
	Three Federal Aviation Agency
Task Selection:	Random Selection

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4.5 CONTRACTOR COLLECTED FIELD DATA

4.5.1 General

As part of another program, Westinghouse collected actual field data on the AN/FPS-27A. The purpose of Westinghouse utilizing these field data as part of this study is to provide a means for assessing the actual field corrective maintenance actions performed in the field, and to compare these assessments with:

- 66-1/65-110 data.
- $\underline{M}$ demonstration test data.
- $\underline{M}$ predictions.

These data for the AN/FPS-27A were, in general, collected by Westinghouse field service engineers at the equipment installation site. These data were collected immediately after installation of the AN/FPS-27A modification kits at each of these field sites. The field engineer used the $\underline{M}$ Time Report (figure 2) to collect these data. Whenever he was unable to complete a report on a

failure, the Air Force technician associated with the equipment completed the form and, at the first opportunity, reviewed it with the Westinghouse field engineer.

4.5.2 Data

From April through November 1973, a total of 21 M Time Reports were received from field operations. This represents about half of all the corrective repair actions that occurred during that time. Table 19 summarizes this data. As illustrated in this table, there were three bases (designated H, I, and J in table 19) reporting maintenance actions as part of this field collection effort that were not visited by Westinghouse Field engineers as part of this study.

4.6 M PREDICTIONS

4.6.1 General

M predictions were made on all of the equipments being evaluated in this study. MIL-HDBK-472, Procedure II was utilized for the AN/FYQ-47 and AN/GPA-127. Procedure III was employed for the AN/GPA-124 and AN/FPS-27A. The following four paragraphs summarize the results of the predictions for the individual systems.

4.6.2 AN/GPA-127(V) Prediction

The M prediction for this system was done in accordance with MIL-HDBK-472, Procedure II. As outlined in paragraph 3.1.3 (AN/GPA-127(V) Maintenance Concept), the prediction is based on removing the defective major assembly from the cabinet and fault localizing it to the defective component via standard test equipment, and replacing the defective component. Table 20 summarizes the M analysis for the system. Also included in this table are a subassembly component analysis and a failure rate prediction. The failure rates were derived from MIL-HDBK-217B.

TABLE 19

AN/FPS-27A CONTRACTOR COLLECTOR DATA

Base	Report No.	Date	Item	Active Down Time (min)* T_P	T_D	T_I	T_C	Total	Adm Time	Logistic Delay Time	Active Repair Time
I	1	4/26/73	CFAR Channel BD	5	15	2	14	36	–		29
H	2	5/24/73	Monitor Proc BD	2	14	1	2	19	1		16
C	3	7/3/73	Blanker Board	15	25	5	15	60	15		40
C	4	7/5/73	Phase Detector	10	10	10	10	40	225		20
H	5	7/24/73	RF Amplifier	3	12	10	10	35	5	17 days	22
G	6	7/26/73	Summing Amplifier	10	20	10	2	42	–	–	22
H	7	7/31/73	RF Amplifier	3	8	10	10	31	5	12 days	18
H	8	8/1/73	CFAR Channel Bd	1	26	1	1	29	1		27
H	9	8/7/73	CFAR Channel BD	5	21	1	1	28	2		22
E	10	8/12/73	CFAR Channel BD	10	20	10	5	45	5		25
H	11	9/27/73	CFAR Channel BD	2	25	1	9	37	5		34
H	12	10/5/73	Mixer Amplifier	3	13	10	15	41	5	11 days	28
H	13	10/5/73	RF Amplifier	3	11	10	10	34	5	10 days	21
E	14	10/18/73	Variable Gen Amplifier	5	9	5	1	20	7		10
I	15	10/24/73	Variable Gen Amplifier	6	30	·	29	65	·	·	59
I	16	10/24/73	CFAR Channel BD	4	33	·	8	45	·	·	41
I	17	11/3/73	RF Switch	5	55	·	90	150	·	12 days	145
I	18	11/13/73	Summing Amplifier	2	11	5	5	23	·	·	16
I	19	11/14/73	Monitor Proc BD	3	29	·	13	45	·	·	42
J	20	11/19/73	RF Amplifier	·	10	5	5	20	·	·	15
I	21	11/20/73	RF Amplifier	3	21	·	6	30	·	·	27
		Average		4.8	19.9	4.6	12.4	41.7	·	·	32.3

* T_P - Preparation
T_D - Fault Location/Verification
T_I - Item Obtainment
T_C - Fault Correction/Adjustment

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TABLE 20

AN/GPA-127(V) RELIABILITY/MAINTAINABILITY SUMMARY

Unit	No. of Component	Failure Rate ($f/10^6$ hr)	M_{ct} (Minutes)*
Cabinet			
Chassis Mounted Parts	111	7.40	38.9
Blower Assy	1	42.50	62.0
Electronic Control Amplifier			
Chassis Mounted Parts	96	124.69	23.1
Azimuth Range Indicator			
Chassis Mounted Parts	132	389.70	42.4
Drive Coil Assy	1	0.05	54.0
Drive Coil Frame Assy	7	127.87	54.0
Off Center Coil Assy	5	1.04	54.0
Collector Ring Assy	No	Electrical	Parts
Capacitor/Resistor Assy No. 1	35	1.37	54.0
Capacitor/Resistor Assy No. 2	25	0.76	54.0
Resistor Assy	5	0.05	54.0
Capacitor/Resistor Assy No. 3	39	2.57	54.0
Capacitor/Resistor Assy No. 4	12	0.46	54.0
Capacitor/Resistor Assy No. 5	29	2.00	54.0
Capacitor/Resistor Assy No. 6	16	1.32	54.0
Power Supply	126	275.71	32.3
Display Board	5	1.64	15.4
TOTAL	645	979.13	39.5

*Study prediction according to MIL-HDBK-472, Procedure II

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4.6.3 AN/FYQ-47 Prediction

The $\underline{M}$ prediction for the AN/FYQ-47 system was performed utilizing Procedure II of MIL-HDBK-472. The maintenance concept on which the prediction is based is described in paragraph 3.2.3. This concept consists of automatic fault detection via BIT with the occurrence of a fault made known to the operating technician either by an audio or video alarm, and fault isolation to a PCB which is accomplished by using a series of fault diagrams and a specific PCB group replacement scheme. Once the defective board has been isolated, it will be removed from the system and repaired off-line. An operational spare will replace it in the system. Table 21 summarizes the $\underline{M}$ prediction for the EU. Illustrated in this table are:

- The major functional groups of the AN/FYQ-47 EU.
- Their associated failure rates.
- The number of PCB's associated with each group.
- The M_{ct} for the EU and the major functional units.

4.6.4 AN/FPS-27A Prediction

The $\underline{M}$ prediction for the AN/FPS-27A Modification Kit is based on MIL-HDBK-472, Procedure III. Paragraph 3.3.3 describes the maintenance concept on which this prediction is based. Basically, system repair is done by fault isolation to a defective PCB and replacing the defective board with an operational spare. Table 22 summarizes the $\underline{M}$ prediction data for this hardware. Illustrated in this table are the names of potential board faults, their relative weight or frequency of repair based on failure rate, the questionnaire checklist scores for each fault being analyzed, and the resulting predicted M_{ct}.

TABLE 21

AN/FYQ-47 RELIABILITY/MAINTAINABILITY PREDICTION SUMMARY

Assembly Nomenclature	Part Number	Number of PC Boards	(f/10^6 hr)	M_{ct} (Minutes)*
HF/O–I Height Finder Module	PL-1266	79	279.56	15.94
HFC – Height Finder Module	PL-1267	65	93.31	20.39
BRG/BWG – Beacon Reply Module	PL-1270	71	127.18	13.32
ARTG – Elect. Synch' Module	PL-1271	105	81.32	18.54
TDG/MOG – Radar Target Det	PL-1272	132	206.60	24.62
RQG – Quantizer Module	PL-1273	21	23.33	12.15
TPG–OBG – Output Buffer Mod	PL-1268	182	253.24	20.11
MCG/MEM – Memory Control Mod	PL-1269	114	249.44	24.70
ARM – Control Monitor	C-8351		38.28	29.46
Power Supply – Main Unit	PP-6349	3	101.19	61.07
Power Supply – Sub Unit	PP-6350	1	54.79	57.27

$\overline{M}_{ct}$ = 24.32

*Manufacturer's prediction according to MIL-HDBK-472, Procedure II

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4.6.5 AN/GPA-124 Prediction

The $\underline{M}$ prediction for this Coder/Decoder Group utilized Procedure III of MIL-HDBK-472. As discussed in paragraph 3.4.3 (AN/GPA-124 Maintenance Concept), the prediction is based primarily on removing and replacing defective PCB's in the Coder/Decoder Unit with component repair in the ECCM Indicator and the Operator's and Master Control boxes. There are a small percentage of chassis mounted parts in the Coder/Decoder Unit which are not mounted on PCB's and thus require replacement when being maintained. These discrete replacements are primarily located in 1A4, coder/decoder control indicator. However, the synchronizer (1A1), the processor (1A3), and the interconnecting unit (1A5) have discretes mounted on their front panel (lights and switches) and on their mother chassis. Generally, the discretes mounted to the chassis are power transistors requiring large heat sinks. Table 23 summarizes the $\underline{M}$ prediction for this system. Illustrated in this table are:

TABLE 22

AN/FPS-27A M PREDICTION SUMMARY

Fault Item	Relative Wt.	Checklist Score A	B	C	Predicted M_{ct} (minutes)*
1. RF Amplifier	1	37	24	31	35
2. Mixer Amplifier	1	37	24	31	35
3. RF Power Supply	1	54	26	34	9
4. VGA	2	49	24	31	19
5. Channel Board	5	49	24	31	19
6. CFAR Channel Bd.	1	49	24	31	19
7. Phase Detector	1	49	24	31	19
8. A/D Converter	3	49	24	31	19
9. Video Amplifier	1	49	24	31	19
10. Memory	10	41	24	29	30
11. Arith. CFAR	1	41	24	29	30
12. IF Power Supply	1	54	26	34	9
13. DF Power Supply	1	54	26	34	9
14. Synchronizer	1	47	24	29	20
System Total	-	45.1	24.1	31	23

*Manufacturer's prediction according to MIL-HDBK-472, Procedure III.

TABLE 23

AN/GPA-124 MAINTAINABILITY PREDICTION SUMMARY

Unit	Number of Components	Relative Weight (%) (Based on λ)	M_{ct} (Minutes)*
Coder – Decoder Unit			
Electronic Synchronizer – 1A1	982	24	46.7
Signal Data Processor – 1A3	1,697	48	45.4
Control Indicator – 1A4	49	1	77.8
Interconnecting Unit – 1A5	769	23	57.8
Operator's Control Box – 2	18	1	30.9
Master Control Box – 3	76	4	41.3
$\bar{M}_{ct}$		Average =	48.8

*Study prediction according to MIL-HDBK-472, Procedure III

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- The relative weight of each unit's M_{ct} based on the failure rate distribution.
- Number of parts in each unit.
- The basic M_{ct} prediction as derived from the MIL-HDBK-472, Procedure III questionnaire.

Not included in this analysis are the Interrogator - Computer (JIR-1A/TSEC) and the ECCM box. The Interrogator-Computer (KIR-1A/TSEC), housed in the Coder/Decoder Unit, is Government Furnished Equipment (GFE) and the T.O.'s (Maintenance Instructions and Illustrated Parts Breakdown (IPB)) were not available for this study. The ECCM box is not GFE but the T.O.'s were also not available for this unit.

4.7 TECHNICAL ORDERS

In this study, Westinghouse required a means for evaluating the current equipment $\underline{M}$ predictions along with the proposed supplier's equipment maintenance concept. The T.O.'s provided this capability. In this study, Westinghouse utilized primarily two parts of the T.O.'s. These are the Technical Manual, IPB, and the Technical Handbook, Maintenance Instructions. The purpose of employing the IPB was to provide a complete up-to-date listing of each equipment's parts list such that existing hardware reliability and ultimately $\underline{M}$ predictions could be reviewed and updated where necessary.

The Maintenance Instructions were utilized to determine the planned equipment's maintenance concept, the fault determination/isolation processes to be utilized, the actual test equipment required for equipment test, and a comprehensive understanding of the overall repair procedure. In some cases, these handbooks provided an insight into some of the reasons for the field recorded long repair times shown in the Air Force data. Additionally, these Maintenance Instructions were employed to verify the integrity of the $\underline{M}$ predictions. Table 24 summarizes the T.O.'s utilized in this study and their latest revision date.

4.8 AIR FORCE SQUADRON CAPSULE DESCRIPTION

4.8.1 General

As previously stated, 7 Air Force operating squadrons where visited by Westinghouse field service engineers for the sole purpose of collecting data for this study. These squadrons were visited between 5 May 1975 and 20 May 1975. Three days were spent at each of the seven squadrons getting specific answers to specific questions with regard to the 66-1/65-110 data, and coordinating the Air Force technicians responsiveness to the Westinghouse questionnaries, $\underline{M}$ Time Reports, and the MIL-HDBK-472, Procedure III questionnaires. The purpose of this paragraph is to briefly summarize the general characteristics of the operating squadrons visited.

TABLE 24

EQUIPMENT TECHNICAL ORDERS USED IN STUDY

Equipment	Technical Manual, Illustrated Parts Breakdown	Effective Date	Technical Handbook, Maintenance Instructions	Effective Date
AN/GPA-127 (V)	T.O. 31P1-2GPA127-4	1 Nov 1967 Change 18 Dec 1973	T.O. 31P1-26GPA-127-2	1 Nov 1967 Change 28 Sept 1973
AN/FYQ-47	T.O. 31S5-2FYQ-47-4	15 Feb 1972 Change 1 Mar 1974	T.O. 31S5-2FYQ-47-2	15 Feb 1972 Change 1 Mar 1974
AN/FPS-27A	T.O. 31P6-2FPS27-4-1	3 Aug 1964 Change 1 Jun 1973	T.O. 31P6-2FPS-27-2-1	3 Aug 1964 Change 1 Jun 1973
AN/GPA-124	T.O. 31P4-2GPA124-4	15 Sep 1971 Change 30 May 1973	T.O. 31P4-2GPA124-2	15 Sep 1971 Change 30 May 1973

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4.8.2 Squadron Description

As stated above, 7 sites were visited. Four were on the East Coast of the United States and three were on the West Coast. Table 25 summarizes the general profile data for the individual squadrons at the time of the visit. As illustrated, the number of people, both Air Force and civilian, were counted. In general, the civilian people were technical representatives of the various Air Force contractors assigned to the squadron for equipment operational and maintenance assistance. At one base, the Air Defense Command (ADC) shared facilities with the Federal Aviation Agency (FAA). This is noteworthy since tighter FAA performance standards result in more stringent preventative maintenance policies. The distance to the nearest town was also noted. In several cases, this was an influencing factor in maintenance because maintenance personnel on base would call other maintenance personnel or contractor technical assistants who were home and

TABLE 25

SQUADRON DESCRIPTION

Squadron	Date Visited	Number of People		Groups Using Maintenance Facilities	Distance to Nearest Town	Turnover Rate (%)		Unusual (Special)Conditions
		Service	Civilian			1–2 yr	2 or more yr	
* A	5 May 1975 7 May 1975	200	20	ADC	15 miles	30	70	None
* B	19 May 1975 21 May 1975	135	25	ADC	18 miles	30	70	No barracks or housing facility on base for Military Personnel.
C	12 May 1975 14 May 1975	115	16	ADC	40 miles	65	35	None
D	5 May 1975 7 May 1975	104	19	ADC	14 miles	60	40	About 13 days per winter, the road is blocked to base personnel
E	16 May 1975 20 May 1975	149	32	ADC	28 miles	60	40	High wind conditions (clocked at 150 mph). Radar has metal frame radome .
* F	8 May 1975 12 May 1975	133	30	FAA/ADC	18 miles	40	60	None
* G	14 May 1975 16 May 1975	133	25	ADC	22 miles	60	40	Iron deposits in area cause holes in radar coverage. Also, a large body of water in immediate area causes temperature inversion.

* Located on East Coast of United States

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troubleshoot the system over the telephone instead of the individual coming to the base. Another piece of data illustrated is the squadron personnel turnover rate. This has a direct effect on the proficiency in maintenance on a particular piece of equipment of an individual. Finally, any unusual or special squadron conditions were noted.

5. FIELD DATA ANALYSIS

Table 26 is a composite summary of the data presented and edited in Section 4 of this report. This data reflects both field and predictive data assembled under the various operational and support conditions. This section will define the various conditions under which each set of data (field, demonstration, and predictive) was collected, and establishes an operating baseline to which the data can be compared and influential factors identified.

5.1 DEFINITION PROBLEM

In establishing a baseline to which the data in Section 4 can be compared, the definition of terms and conditions under which each set of data was collected must be established. For example, MIL-HDBK-472, Procedure II predicts repair time required to perform a corrective maintenance action based on data gained in past experience (time line analysis). MIL-HDBK-472, Procedure III predicts M_{ct}'s of individual tasksbased on a checklist approach. Neither of these predicted times is exactly the same as the "Unscheduled Maintenance Time" recorded as a category of "Downtime" in the 66-1/65-100 Air Force data. Additionally, the $\underline{M}$ Demonstration Test data and the contractor collected field data also reflect a slightly different frame of reference. Since the study will compare M_{ct} developed from $\underline{M}$ predictions with M_{ct} as extracted from field records, the initial step is to establish a common M_{ct} baseline. For the purposes of this study, only the definitions as they are defined in MIL-STD-721B pertaining to corrective maintenance will be used. Figure 10 (taken from MIL-STD-721B) shows the relationship of the various categories of M_{ct} which are defined as follows:

TABLE 26

EQUIPMENT QUANTITATIVE DATA BASE SUMMARY

Equipment	Average Corrective Maintenance Time					
	Prediction per MIL–HDBK-472	Air Force Field Collected Data (66-1/65-110) (Subassembly w crew size)	AF Maintenance Technicians: (a) Prediction $\bar{M}$ Time Report	AF Maintenance Technicians: Estimates MIL-HDBK-472 Proc.III Quest	Maintainability Demonstration Test Data	(b) Contractor Collected Field Data
AN/GPA-127(V)						
Cabinet	58.6	145.8	–	–	None Conducted	None Collected
Electronic Control Ampl	23.1	63.0	–	–		
Azimuth Range Indicator	45.4	219.6	–	–		
Power Supply	32.3	91.8	–	–		
Display Board	15.4	–	–	–		
Total	39.5	148.2	108.2	N/A		
AN/FYQ-47	24.3	121.8	117.9	N/A	$\bar{M}_{ct}$ = 17:47	None Collected
AN/FPS-27A	23.0	111.6	116.0	134.0	$\bar{M}_{ct}$ = 26.1 M_{ct} (max) = 58.8	M_{ct} = 32.3
AN/GPA-124						
Coder-Decoder Unit					None Conducted	None Collected
Electronic Synchronizer	46.7	136.2	–	–		
Interrogator-Computer	N/A	46.2	–	–		
Processor	45.4	87.6	–	–		
Control Indicator	77.8	102.0	–	–		
Interconnecting Unit	57.8	78.0	–	–		
Operator's Control Box	30.9	19.8	–	–		
Master Control Box	41.3	30.0	–	–		
Total	48.8	93.0	112.8	121.0		

(a) Data includes preparation and cleanup times, but does not include Administrative and Item Obtainment Times

(b) Data includes preparation time.

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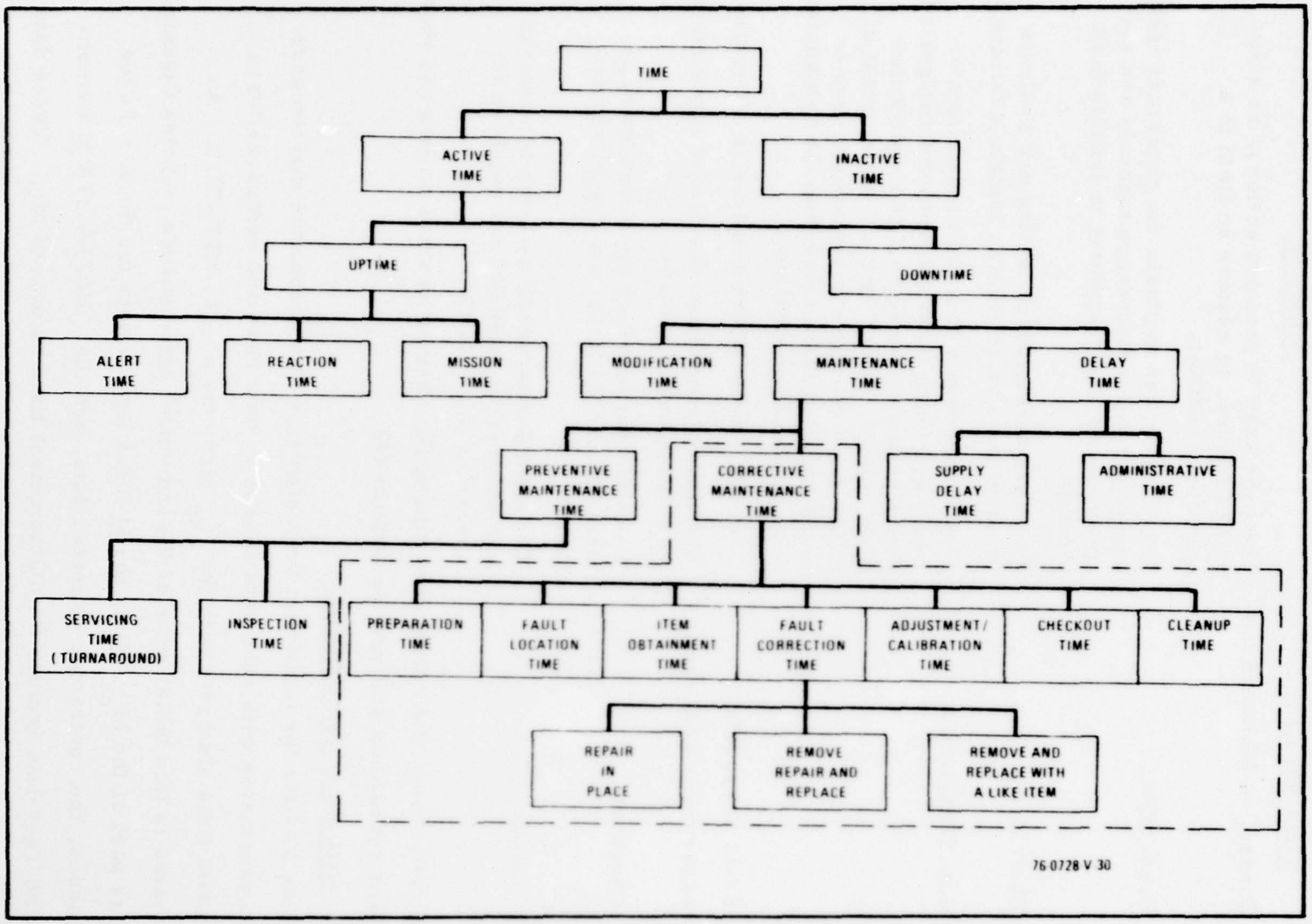

Figure 10. MIL-STD-721B Definition of Terms

Time Element	Definition
• Corrective Maintenance	The time used to perform actions, as a result of failure, to restore an item to a specified condition.
• Preparation	The time needed to obtain the necessary test equipment and maintenance manuals and set up the necessary equipment to initiate fault location.
• Fault Location	The time during which testing and analysis is performed on an item to isolate a failure.
• Item Obtainment	The time during which the needed item or items are being obtained from the designated organization stockrooms. (As contracted with "Supply Delay Time": That element of Delay Time during which a needed item is being obtained from other than the designated organizational stockroom.)
• Fault Correction	The time during which a failure is corrected.
• Adjustment Calibration	The time during which the needed adjustments or calibrations are made.
• Checkout	The time during which performance of an item is verified to be in a specified condition.
• Cleanup	The time during which the item is enclosed and extraneous material not required for operation is removed.

Using definitions, the differences among the various sources of data and these standard definitions will now be established.

5.1.1 Data Base Comparison

Table 27 lists the individual time elements of a corrective maintenance action associated with each data source or data base and compares these individual time elements with the M_{ct} elements of MIL-STD-721B. As illustrated in this table, none of the individual data sources includes Cleanup time as part of the M_{ct}. Only the M Time Report data for the Air Force technicans, the contractor collected data, and the AN/FPS-27A M Demonstration Test data include Item Obtainment time as part of M_{ct}. These data

TABLE 27

DATA BASE TIME

MIL-STD 721B	MIL-HDBK-472 Procedure II	(1) MIL-HDBK-472 Procedure III; (2) Procedure III Field Questionnaires	(1) AF Technician M Time Reports (2) Contractor Coll. Field Data; (3) AN/FPS-27A M Demo Test Data	AN/FYQ-47 M Demo Test Data	A.F. Data (66-1/65-110)
Preparation		Preparation	Preparation		
Fault Location	Localization Isolation Disassembly	Fault Location	Fault Location/ Verification	Isolate	Troubleshooting, Equipment Checked-No Repair Required, Calibrated-No Adj. Required
Item Obtainment		Item Obtainment			
Fault Correction	Interchange Reassembly	Fault Correction	Fault Correction/ Adjustment	Repair	Repair, Repair and/or Replacement of Minor Parts, Adjust, Removed, Installed, Remove and Replace, Remove and Reinstall
Adjustment/ Calibration	Alignment	Adjustment/ Calibration			
Checkout	Checkout	Final Test		Confidence	
Cleanup					

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along with data gathered according to MIL-HDBK-472, Procedure III, contain Preparation Time as part of M_{ct}. When making comparisons between data sources for factor determination and mathematical mode representation, these differences, together with those discussed in the following paragraphs, must be noted and the proper adjustments made.

5.1.2 MIL-HDBK-472, Procedure II

The fundamental philosophy in this prediction technique is that the magnitude of the repair time, for a discrete repair, is the sum of the individual maintenance task times which are required for its completion. Seven such maintenance tasks are assumed to effect the magnitude of maintenance time. These are:

- Localization.
- Isolation.
- Disassembly.
- Interchange.
- Reassembly.
- Alignment.
- Checkout.

Not included in this list as defined in MIL-STD-721B for corrective maintenance are:

- Preparation.
- Item Obtainment.
- Cleanup.

Moreover, the distinction between Fault Location and Fault Correction in MIL-STD-721B and Localization, Isolation, Disassembly, Interchange and Reassembly is not clean cut. However, for this analysis they were considered to envelop the same aspects of the diagnostic/repair procedure.

5.1.3 MIL-HDBK-472, Procedure III

The underlying philosophy of this procedure is that system failures are principally due to malfunction of replaceable items and therefore, the time

cycle for the various steps required to replace these items is a measure of downtime. The duration of this downtime is assumed to be a function of specific design parameters which relate to:

- The physical system configuration.
- The facilities provided for maintenance by the design.
- The degree of maintenance skills required of personnel charge with the repair.

The assignment of times of performance of each of the steps involved in the maintenance cycle is determined by utilizing 3 checklists, each one being related to one of the specific design functions just described (physical system configuration, facilities, personnel). In this prediction process, it is assumed that similar types of maintenance tasks required the same maintenance steps, i.e., Preparation, Fault Location, Fault Corrective, Adjustment/Calibration, and Final Test. It should be noted that the basic maintenance task times inferred in the Procedure III checklists correspond in majority directly with the MIL-STD-721B corrective maintenance task times. Not included as part of Procedure III corrective maintenance task times are Item Obtainment and Cleanup. For this study, it is assumed that the Checkout time as defined in MIL-STD-721B is the same time element as Final Test as defined in MIL-HDBK-472, Procedure III.

5.1.4 Contractor Collected Field Data

The maintenance times recorded as part of each maintenance task included Preparation, Fault Location/Verification, and Fault Correction/Adjustment. Collected as part of each maintenance action but not included in the final field data analysis were Item Obtainment times. For this field data only the definitions of Preparation and Item Obtainment times are in agreement with MIL-STD-721B definitions. However, it can be seen that Fault Correction/ Adjustment is equivalent to the sum of MIL-STD-721B's Fault Correction and Adjustment times. Similarly, Fault Location/Verification is equivalent to the

sum of Fault Location plus Checkout as defined in MIL-STD-721B. Not included as part of this field collected data M_{ct} is MIL-STD-721B's Cleanup.

5.1.5 M Time Reports and Procedure III Questionnaires

This data, as discussed in paragraph 4.3, was collected as representing typical field corrective maintenance actions. The M Time Report has the same format and time element as the contractor collected field data. Thus, the time element analysis for the M Time Reports is identical to the one for the contractor collected field data (paragraph 5.1.4). The Procedure III questionnaire is identical to the MIL-HDBK-472, Procedure III questionnaire, thus the time element analysis for these questionnaires is the same as that in paragraph 5.1.3.

5.1.6 Maintainability Demonstration Test Data

The M Demonstration Test data for the AN/FPS-27A utilized time elements similar to those of MIL-STD-721B as did the contractor collected field data, i.e., Preparation, Fault Location/Verification, and Fault Correction/Adjustment. As defined in paragraph 5.1.4, when these terms are compared with MIL-STD-721B, only Cleanup as defined in this military standard has been excluded from this data.

The M Demonstration Test data elemental repair times for the AN/FYQ-47 were divided into three basic time segments: time to Isolate, time to Repair, and time to perform a Confidence Check. When comparing these times with the standard definitions for corrective maintenance, it can be found that Preparation, Item Obtainment, and Cleanup were not included in the demonstration data. The remaining time elements of MIL-STD-721B can then be associated with the AN/FYQ-47 M Demonstration Test time elements as follows:

- Fault Location as defined in MIL-STD-721B is equivalent to time to Isolate.
- Fault Correction plus Adjustment/Calibration as defined in MIL-STD-721B is equivalent to time to Repair.
- Checkout as defined in MIL-STD-721B is equivalent to time to perform a Confidence Check.

5.1.7 Air Force Data

The basic data about malfunctions and repair in the field are derived from two sources: Equipment Status Reports (ESR's) collected according to AFM 65-110, and Maintenance Data Collection Reports (AFTO 349) collected according to AFM 66-1. The latter data is aggregated into a report, Report from the Assistant DCS Comptroller for Command Automated Systems. The ESR reports were used to disaggregate the data in the Report from the Assistant... since the latter report has combined the original AFTO 349 information on total EMT with crew size to yield manhours. The maintenance action data from the AFTO 349 forms identified how long and what maintenance took place. The codes used to explain the actions refer to concepts which are analogs to the MIL-STD-721B definitions but differ sufficiently to required discussion. The process of data reporting and collection is discussed in detail in Appendix I. Maintenance technicians are required to describe their corrective maintenance actions by a code letter on the AFTO 349 form.

A brief listing of some of the terms and code letters is shown below:

Action Taken	Code Letter
Repair (not used for an equipment if any other code applies)	F
Repair and/or Replacement of Minor Parts	G
Equipment Checked - No Repair Required	H
Calibrated-No Adjustment Required	J
Calibrated-Adjust Required	K
Adjust	L
Removed	P
Installed	Q
Remove and Replace	R
Remove and Reinstall	S
Troubleshoot	Y

The eleven categories listed are those most closely resembling the MIL-STD-721B definitions for maintenance events. Since the AFM 66-1 document is concerned with maintenance operation, the reporting categories reflect a concern with what the technician did and what item was at fault rather than an interest in the elements of the repair action. Thus the Action Taken codes are much more precise about how a fault is corrected than the MIL-STD-721B description. There are, however, no codes for 3 of the maintenance action events: Preparation, Item Obtainment and Checkout. The definitions used to report maintenance action taken do not contradict the maintenance events of MIL-STD-721B, but breaking out the elemental times in maintenance events according to the MIL-STD-721B categories cannot be done. The definitional relationships of the two perspectives are shown below:

MIL-STD-721B Category	AFTO 349 Categories
Preparation	not defined
Fault Location	Troubleshooting, Equipment Checked-No Repair Required, Calibrated-No Adjustment Required
Item Obtainment	not defined
Fault Correction, Adjust/ Calibration, Checkout	Repair, Repair and/or Replacement of Minor Parts, Adjust, Removed, Installed, Remove and Replace, Remove and Reinstall.
Cleanup	not defined

Although the AFTO 349 reports are organized around a different perspective than the MIL-STD-721B definitions, the above grouping shows there is no contradiction between the aggregate time category M_{ct} as discussed in MIL-STD-721B and the sum of the Action Taken-Maintenance codes for on equipment maintenance. Additionally, Preparation, Item Obtainment, and Cleanup Times, although not AFTO 349 defined categories, are included as part of the overall EMT. This occurs since, by definition, EMT covers the time invested from the start to the finish of a maintenance action.

5.1.8 Summary

The preceding paragraphs, aided by table 27, have detailed the maintenance time elements definition differences among the various sources of data and have referenced these definitions relative to the categories of MIL-STD-721B. It is now possible to procede in analyzing these data.

5.2 FIELD DATA ANALYSIS

Before analyzing the data base for identifying field influencing factors on $\underline{M}$, it was first necessary to establish a definitional frame of reference. Once this was accomplished, as discussed in paragraph 5.1, additional adjustments to the Air Force field data were required. Specifically, these adjustments consisted of deleting four types of time elements:

- Mechanical Repair.
- Extreme Cases.
- Administrative Delay.
- No Defect.

For example, mechanical failures such as gears recorded in the 66-1/65-110 data are traditionally not part of the equipment $\underline{M}$ predictions since failure rates are not assigned to pure mechanical parts. Thus, adjustments either to the predictions or to the Air Force field data must be made. Secondly, there were certain events that covered extremely long periods of time when compared with other field data on the same units as witnessed in the Air Force data while events that took less than three minutes were not by practice recorded in the 66-1/65-110 maintenance reporting scheme. The long periods of corrective maintenance could be attributed to:

- Multiple failures.
- Poor start in diagnostic procedures.
- Failure of BIT circuitry not detected by the visual or audio system fault indicators.

Thirdly, as determined by Westinghouse field visits, administrative time crept into the recorded field M_{ct}. False alarms (no-defects) require a

fourth adjustment to the Air Force field data. In many cases, the fault detection circuitry in the equipment indicated a system fault. However, upon performing corrective maintenance no defects were found. These false alarms could be attributed to a misreading by operational personnel of the equipment visual fault indicators, or a detected fault by the Built-In Test Equipment (BITE) which was, in reality, not a fault. This latter condition in some instances was attributed to a fault in the output of an equipment associated with the input of the equipment being studied. This would give the initial indication of a fault in the equipment being studied instead of the actual defective equipment. Also, tight thresholds in the equipment's BITE which are very sensitive and thus triggered by power transients on the input power lines also provided a small portion of these false alarms. The summary of the results of purging the Air Force data for these conditions is exhibited in table 28. Details on why and how this data were purged are given in paragraphs 5.2.1 through 5.2.4.

5.2.1 Mechanical Repair

A precise $\underline{M}$ prediction for a system includes a frequency of failure prediction used for weighting the maintenance activities, plus an evaluation with respect to time of the individual corrective maintenance activities which is generally done either by a time line analysis (Procedure II) or by a questionnaire (Procedure III). In general, for electrical and electro-mechanical devices, this can be done. However, for strictly mechanical devices, there is no means to incorporate the proper weighting of the potential failure mechanism of the mechanical device into the prediction. For this reason, data recorded in the 66-1/65-110 maintenance data system reflecting such mechanical corrective maintenance actions should be purged from the overall data. Such was the case for the AN/GPA-127(V) Azimuth Range Indicator. These were 8 strictly mechanical corrective maintenance actions totaling 71.9 hours of repair in the time period evaluated for this subassembly. The particular mechanical device being replaced was the Azimuth Range Indicator's

TABLE 28

SUBASSEMBLY SEMISCREENED TO SCREENED DATA SUMMARY

	Semiscreened Data		No Defects		Mechanical Repairs		Extreme Cases		Administrative Times		Screened Data		
Equipment	Number of Events	Correct Maint Time	Number of Events	Correct Maint Time	Number of Events	Correct Maint Time	Number of Events	Correct Maint Time	Number of Events	Correct Maint Time	Number of Events	Correct Maint Time	Avg Repair Time/Incident
AN/GPA-127(V)	142	351.3	8	9.1	8	71.9			126	21	126	249.3	1.98
AN/FYQ-47	170	344.8	33	128.9	1	2.7	1	83.8	135	22.5	135	106.9	0.79
AN/FPS-27A	90	167.4	12	10.7					78	13.0	78	145.4	1.86
AN/GPA-124	71	110.1	3	55.1					68	9.2	68	45.8	0.67

All times given in hours

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gear train. As illustrated in figure 11, once the Azimuth Range Indicator is removed from the AN/GPA-127(V) cabinet, replacement of the gear train is complex and thus time consuming. These 8 corrective maintenance actions total only 5.8 percent of the corrective maintenance actions recorded on the AN/GPA-127(V); however, they total to 21.3 percent of the total M_{ct}. One strictly mechanical failure was recorded on the AN/FYQ-47 which totaled 2.7 hours. No mechanical failures were reported on the AN/GPA-124, or the AN/FPS-27A.

5.2.2 Extreme Cases

Neither the AN/GPA-124, the AN/FPS-27A, nor the AN/GPA-127(V) had any unusually long corrective maintenance times. However, the AN/FYQ-47 had 1 corrective maintenance action that took a total of 83.3 hours. Of this time, 80.8 hours was attributed to troubleshooting. As discussed in paragraph 4.4.2, the reason for this extremely long corrective maintenance time

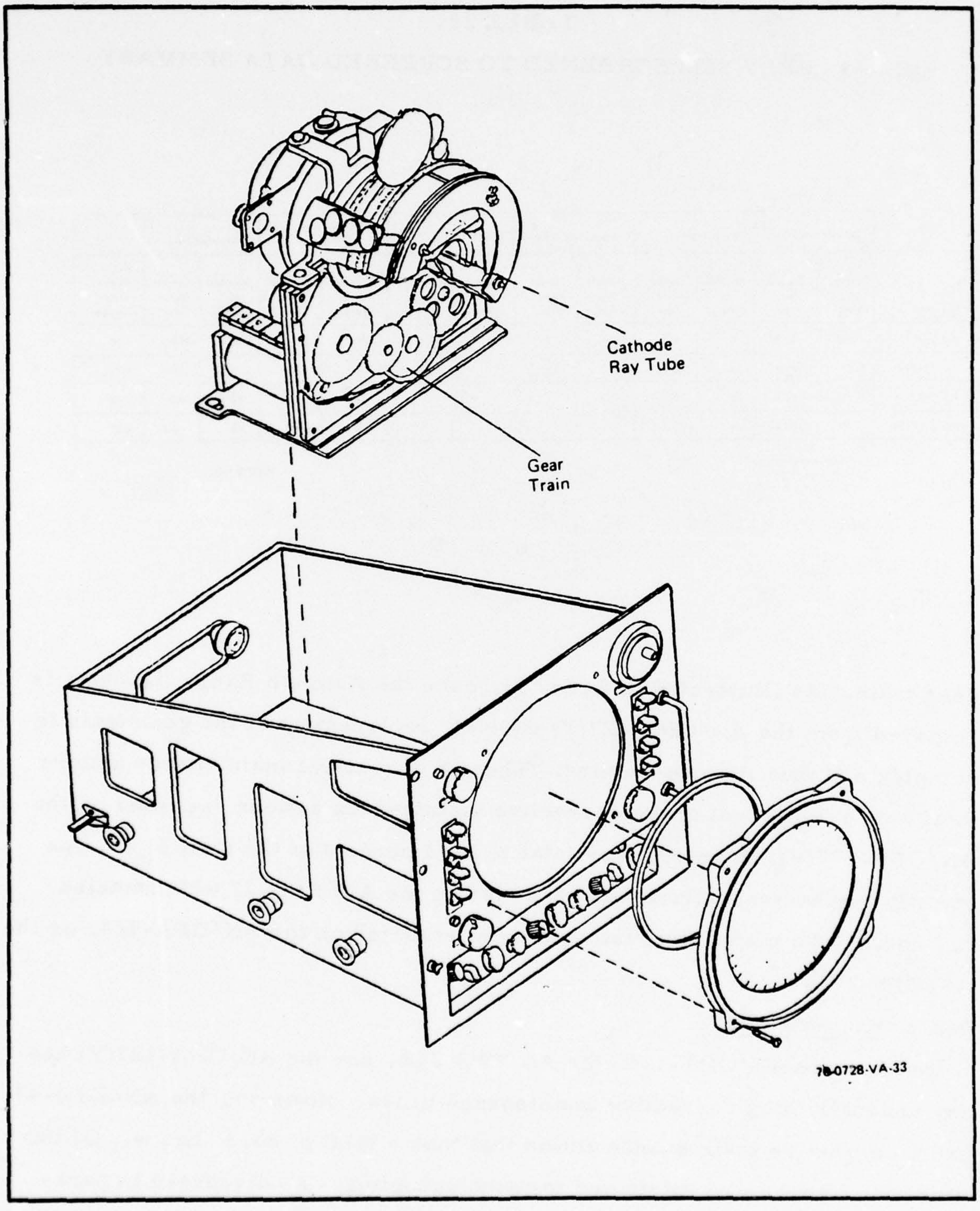

Figure 11. AN/GPA-127(V) Azimuth Range Indicator
Gear Train Replacement

(and particularly the troubleshooting time) could be attributed to a misleading failure symption causing the maintenance team to look in the wrong areas. Since this action was not typical of field maintenance, it was purged from the numerical data.

5.2.3 Administrative Delay

None of the corrective maintenance definitions as defined in section 5.1 were supposed to include administrative time. This includes times attributed to general data recording procedures and the mechanics of recording time initiated against clock seconds involving shifting from maintenance status to delay status and back again. Data collected during Westinghouse supervised AN/FPS-27A modification operations indicated that sometimes an equipment was functionally in a Delay mode due to a need for the technician to do something other than maintenance. However, if this shift in functional status took place between direct maintenance events and was of short duration, the delay status was not recorded. Such cases of delay time inclusion in maintenance time were common enough to be considered. Also, administrative time involved in completing maintenance records was also attributed directly to M_{ct}. Results of both the Westinghouse field questionnaire and the AN/FPS-27A contractor collected data substantiated this. As shown in table 19 this Administrative time under contractor supervision averages to 5 minutes. Referring to table 12, the results of the survey of Air Force technicians at the 7 visited operating squadrons, this average administrative time can be estimated to be 11.8 minutes. This excluded all times in table 12 that exceeded 20 minutes since those times, in most probability, should have been recorded as delay times due to lack of a spare part, test equipment, or four some other logistics cause. For the purging of the data set discussed in Section 4.1 which will be utilized as the Air Force field data for this study, this administrative time was estimated to be 10 minutes per action and thus removed from the Air Force field unscreened data as shown in table 28.

5.2.4 No Defects

There were a significant number of field M_{ct}'s per equipment in which no faults (component failures) were found. As discussed in paragraph 5.2, this could be attributed to faulty input data, power transients resulting in BITE false alarms, or errors in reading the equipment's visual fault indicators. These times should be eliminated from the field data since they do not represent equipment repair. Table 29 shows the average unscreened M_{ct} for each equipment and the average time spent on each of these false alarms. As illustrated, the AN/GPA-124 average M_{ct} for no defects data was nearly 12 times that of the unscreened data. The difference in these two averages for the other three equipments is not statistically different. The noticeable difference between the AN/GPA-124 averages may be attributed to a lack of an elaborate and detailed BIT, packaging not conducive to troubleshooting ease, and vaguely written manuals.

5.3 PREDICTION VARIABILITY

In making $\underline{M}$ predictions by the methods described in MIL-HDBK-472 or any other method, there are basic design and support features that must be evaluated. In many cases this evaluation is done prior to the actual prediction of the equipment involved, and thus a large portion of this evaluation process is very subjective. From the day of the prediction to the day of production and ultimately deployment, changes in both mechanical and electrical design could significantly effect the results of the evaluation. Also, failure frequency variability from prediction to field experience could also impact the accuracy of the particular evaluation. Such things as maintenance induced failures, wearout of mechanical items, and variations in thermal and even electrical environments could contribute to this aspect. Finally, a variation in the initial proposed maintenance concept on which the prediction was based could also contribute to the field prediction difference. The remainder of this section discusses the possible quantitative variability in the prediction processes of MIL-HDBK-472, Procedures II and III. This discussion is

TABLE 29

NO DEFECT DATA COMPARISON

Equipment	Number of Events	Total Time (Hours)	Average Time Spent/Event (Hours)
AN/GPA-127(V)			
AF Unscreened Data	142	351.3	2.47
No Defect Data	8	9.1	1.14
AN/FYQ-47			
AF Unscreened Data	170	344.8	2.03
No Defect Data	33	128.9	3.91
AN/FPS-27A			
AF Unscreened Data	90	107.4	1.86
No Defect Data	12	10.7	0.89
AN/GPA-124			
AF Unscreened Data	71	110.1	1.55
No Defect Data	3	55.1	18.37

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presented here for the sole purpose of highlighting the potential variability that can be realized by making a $\underline{M}$ prediction on a particular piece of equipment.

5.3.1 MIL-HDBK-472, Procedure II

5.3.1.1 General

The methodology for Procedure II starts with a synthesized repair sequence for M_{ct}. Each system element evaluated for repair has a failure frequency (λ), a repair time (R_p) and the logarithm of repair time ($\log R_p$) estimated for it. The elemental repair times and failure rates are then algebraically related to yield an MTTR in equation (5.1).

$$MTTR = \frac{\Sigma \lambda_i \, (R_{pi})}{\Sigma \lambda_i}, \qquad (5\text{-}1)$$

where = i designates the i^{th} unit of repair.

If repair times are distributed lognormally, ERT (a median repair time) is estimated as follows:

$$\text{ERT} = \text{Antilog} \; \frac{\left[\Sigma \lambda_i \log R_{pi}\right]}{\Sigma \lambda_i} . \tag{5-2}$$

The standard deviation of the logarithm of the repair time (σ) is estimated as follows:

$$\sigma = \sqrt{\frac{1}{1.15} \log \frac{(\text{MTTR})}{\text{ERT}}} \tag{5-3}$$

The maximum repair time (the 95th percentile of a lognormal distribution) is:

$$R_{pmax} \text{ (95th \%)} = \text{ERT EXP} \left[1.645 \; \sigma / 0.434\right] . \tag{5-4}$$

5.3.1.2 Field Technician Procedure II Predicted M_{ct} Distribution Parameter Estimates

If we use the table 12 first row active repair time data as raw sample repair times, the median repair time of the AN/FYQ-47 can be estimated as follows:

$$\text{Antilog} \; \frac{\left[\log 40 + \log 85 + - - - - + \log 112\right]}{14}$$

$$= 85.297 \text{ minutes.}$$

Since the field technician estimated active MTTR is 99.4,

$$\sigma = \sqrt{\frac{1}{1.15} \log (99.4/85.297)} = 0.24, \text{ and}$$

$$R_{pmax} = 85.297 \text{ EXP} \left[1.645 \; (0.24)/0.434\right]$$

$$= 211.8 \text{ minutes.}$$

Similarly, the estimated lognormal distribution parameters of the other three equipments can be estimated and listed in table 30.

TABLE 30

PROCEDURE II FIELD TECHNICIAN PREDICTED ACTIVE REPAIR TIME DISTRIBUTION PARAMETER ESTIMATES*

	MTTR	ERT	σ	R_{pmax} (95%)
AN/GPA-127	86.2	67.881	0.3	211.6
AN/FYQ-47	99.4	85.297	0.24	211.8
AN/FPS-27A	94.1	77.859	0.268	215.0
AN/GPA-124	93.8	86.010	0.181	170.8

*The distribution is assumed to be lognormal.

5.3.2 MIL-HDBK-472, Procedure III

5.3.2.1 General

The predicted downtime, M_{ct}, for each maintenance task is calculated by performing a M analysis of the particular task. This analysis requires a step-by-step accounting of a logical diagnostic procedure to isolate the fault, to replace the defective assembly, module, or component, and to checkout the system. This procedure uses numerical scores which are assigned by following the scoring criteria of applicable checklists. Specifically these checklists are:

- Scoring physical design factors.
- Scoring design dictates facilities.
- Scoring design dictates maintenance skills.

The numerical scores are translated into a quantitative measure of downtime, M_{ct} in minutes, by substituting the scores into the equation given on page 3-31 of MIL-HDBK-472:

$$M_{ct} = \text{Antilog}\,(3.54651 - 0.02521A - 0.03055B - 0.0193C) \qquad (5\text{-}5)$$

where

A = qualitative score for physical design features

B = qualitative score for design dictates facilities

C = qualitative score for design dictates - maintenance skills

Checklist A, as previously stated, determines the impact of the physical design features of the equipment on M_{ct} through the evaluation of the following features:

- External access.
- External latches and fasteners.
- Internal latches and fasteners.
- Internal access.
- Packaging.
- Manner in which parts are removed or replaced during maintenance action.
- Visual displays.
- Fault and operation indicators.
- Availability of test points.
- Identification of test points.
- Labelling.
- Adjustments after maintenance.
- In-circuit testing.
- Protective devices.
- Safety.

Checklist B determines the dependency of the system maintenance tasks on external facilities such as test equipment, technical assistance, and supervision. Specifically, the features evaluated in this checklist are:

- External test equipment.
- Connectors to test equipment.
- Jigs or fixtures.
- Visual contact.
- Assistance from operations personnel.
- Assistance from technical personnel.
- Assistance from supervisors or contract personnel.

Checklist C determines the impact of personnel characteristics on M_{ct} through the evaluation of the following features:

- Arm, leg, and back strength.
- Endurance and energy.
- Eye-hand coordination, manual dexterity, and neatness.
- Visual acuity.
- Logical analysis.
- Memory-things and ideas.
- Planfulness and resourcefulness.
- Alertness, cautiousness, and accuracy.
- Concentration, persistence, and patience.
- Initiative and incisiveness.

The scoring for each check point (feature) in each checklist has a range from 0 to 4. If the feature is not applicable, a maximum score of 4 is used.

5.3.2.2 Prediction Sensitivity

Although M_{ct} can easily be calculated by equation (5-5), the effect of a change in the A, B, or C scores on M_{ct} is not clearly evident. An alternative expression for M_{ct} is:

$$M_{ct} = \frac{3,519.7353}{(1.05946)^A (1.072877)^B (1.025487)^C} \tag{5-6}$$

This equation has been used to prepare table 31 which illustrates the change in M_{ct} (ΔM_{ct}) based on changes in checklists A, B, and C ranging from -12 to +12. For example, if the checklist A score is reduced by 4 ($\Delta A = -4$), the predicted value of M_{ct} is increased by the multiple 1.2603. A reduction of each of the A, B, and C scores by -4 would result in the predicted value of M_{ct} being multiplied by: 1.2603 X 1.3250 X 1.059 = 1.8467. An increase of each of the A, B, and C scores by 4 would result in the predicted value of M_{ct} being multipled by: 0.7935 X 0.7547 X 0.9042 = 0.5415. A closer look at table 31 shows that any variability in the external facilities features of a piece of equipment (checklist B) has more of an impact on the predicted M_{ct}

TABLE 31

EFFECT OF CHANGE OF A, B, AND C SCORES ON M_{ct}

A	M_{ct} (Multiple)	B	M_{ct} (Multiple)	C	M_{ct} (Multiple)
-12	2.0019	-12	2.3259	-12	1.3525
-11	1.8894	-11	2.1680	-11	1.3190
-10	1.7832	-10	2.0207	-10	1.2861
-9	1.6829	-9	1.8834	-9	1.2542
-8	1.5884	-8	1.7554	-8	1.2230
-7	1.4991	-7	1.6363	-7	1.926
-6	1.4149	-6	1.5251	-6	1.630
-5	1.3354	-5	1.4215	-5	1.1341
-4	1.2603	-4	1.3250	-4	1.1059
-3	1.1895	-3	1.2349	-3	1.0784
-2	1.1226	-2	1.1511	-2	1.0516
-1	1.0595	-1	1.0729	-1	1.0254
0	1.0000	0	1.0000	0	1.0000
1	0.9438	1	0.9321	1	0.9751
2	0.8908	2	0.8688	2	0.9509
3	0.8407	3	0.8097	3	0.9273
4	0.7935	4	0.7547	4	0.9042
5	0.7489	5	0.7034	5	0.8818
6	0.7068	6	0.6557	6	0.8598
7	0.6670	7	0.6112	7	0.8385
8	0.6296	8	0.5696	8	0.8176
9	0.5942	9	0.5309	9	0.7973
10	0.5608	10	0.4949	10	0.7775
11	0.5292	11	0.4613	11	0.7581
12	0.4995	12	0.4299	12	0.7393

than an equal amount of variability in the physical design features (checklist A) or the personnel requirements (checklist C). Likewise, any variability in the physical design features (checkist A) has more of an impact on the calculated M_{ct} than an equal amount of variability in the personnel requirements (checklist C).

As can be seen, this technique is specific as far as intent goes, but there is potential for some degree of variability from one analysis to another.

6. IDENTIFICATION OF INFLUENCES AFFECTING FIELD MAINTAINABILITY

The object of this section is to identify the factors affecting field maintainability and their relative degree of influence. These factors were identified by examining various sources of field data, correlating these data base sources, and determining what caused the disparity between the equipments' predicted MTTR's and the field reported M_{ct}'s for the various data sources. Since Air Force reported $\overline{M}_{ct}$ includes many time elements beyond the manufacturer's (or designer's) control, we shall divide the factors into two major classes — operational and manufacturer. In order to separate the repair time frame into two regions, the term "rated $\overline{M}_{ct}$ is used as a partitioner. Rated $\overline{M}_{ct}$ is an inherent equipment $\overline{M}_{ct}$ characteristic, the result of a manufacturer's design effort in software as well as in hardware. The main difference between the manufacturer's predicted $\overline{M}_{ct}$ and Air Force reported $\overline{M}_{ct}$ is due to operational factors; consequently, greater emphasis shall be focused on the determination of the latter. The following paragraphs describe the general approach to this problem. Paragraphs 6.1 through 6.4 present detailed discussion as to how each factor was derived from the various data bases.

The initial approach for factor determination was to display the quantitative relationships between the various data collected. The findings from tables 11, 12, 13, 19 and 26 are summarized in figure 12 which profiles the differences between reported and predicted repair times associated with the four equipments under study. The ranges associated with each predicted or reported average repair time indicate the variability of the estimated average repair times. As shown, there are broad variations within a data source when referenced to either inter-equipment and/or inter-base

relationships. These variations establish the basis for factor identification. Notice that Base E field technician predicted $\overline{\overline{M}}_{ct}$'s for both Procedures II and III are lower than that at any other bases. Similarly Base F field technician predicted $\overline{\overline{M}}_{ct}$'s for Procedures II and III are the second highest and highest among all the bases. This shows the base influence is the most important operational factor. One of the simplest ways to analyze the base influence is to study the questionnaires that show distinct contrast in responses between Base E and Base F. Similarly, figure 12 shows that the AN/GPA-127(V) field reported $\overline{M}_{ct}$ is the highest and that of the AN/GPA-124 is the lowest. Consequently, the operational differences among equipments can be analyzed by studying those questionnaires that show distinct contrast in responses between these two equipments.

Figure 12 also points out that for each given prediction method (Procedure II or III), field technician predicted $\overline{M}_{ct}$ may vary up to 370% from the four equipment combined prediction average ($\overline{\overline{M}}_{ct}$) due to operating site difference or personnel performance. However, the combined prediction average $\overline{M}_{ct}$ for each of the four equipments is within 8% of the predicted $\overline{\overline{M}}_{ct}$ for both prediction Procedures II and III. In addition, both Procedure II and III predicted $\overline{\overline{M}}_{ct}$'s are within 8% of the average Air Force reported $\overline{\overline{M}}_{ct}$ with the former slightly more optimistic and the latter more conservative. This indicates that the $\overline{M}_{ct}$ difference among the four equipments is comparatively small.

Once these variations have been established, correlation with the various data sources and in particular the field interviews can be established. Table 32 specifically defines the broad ranges of variability between both equipments and bases. As shown, inter-equipment variability between data sources is not nearly as severe as inter-base variability. Thus, the predominant operational influences affecting field maintainability can be attributed to the inter-base effect. To a lesser degree, variability between equipment types is influential. Table 33 defines the entire list of influences

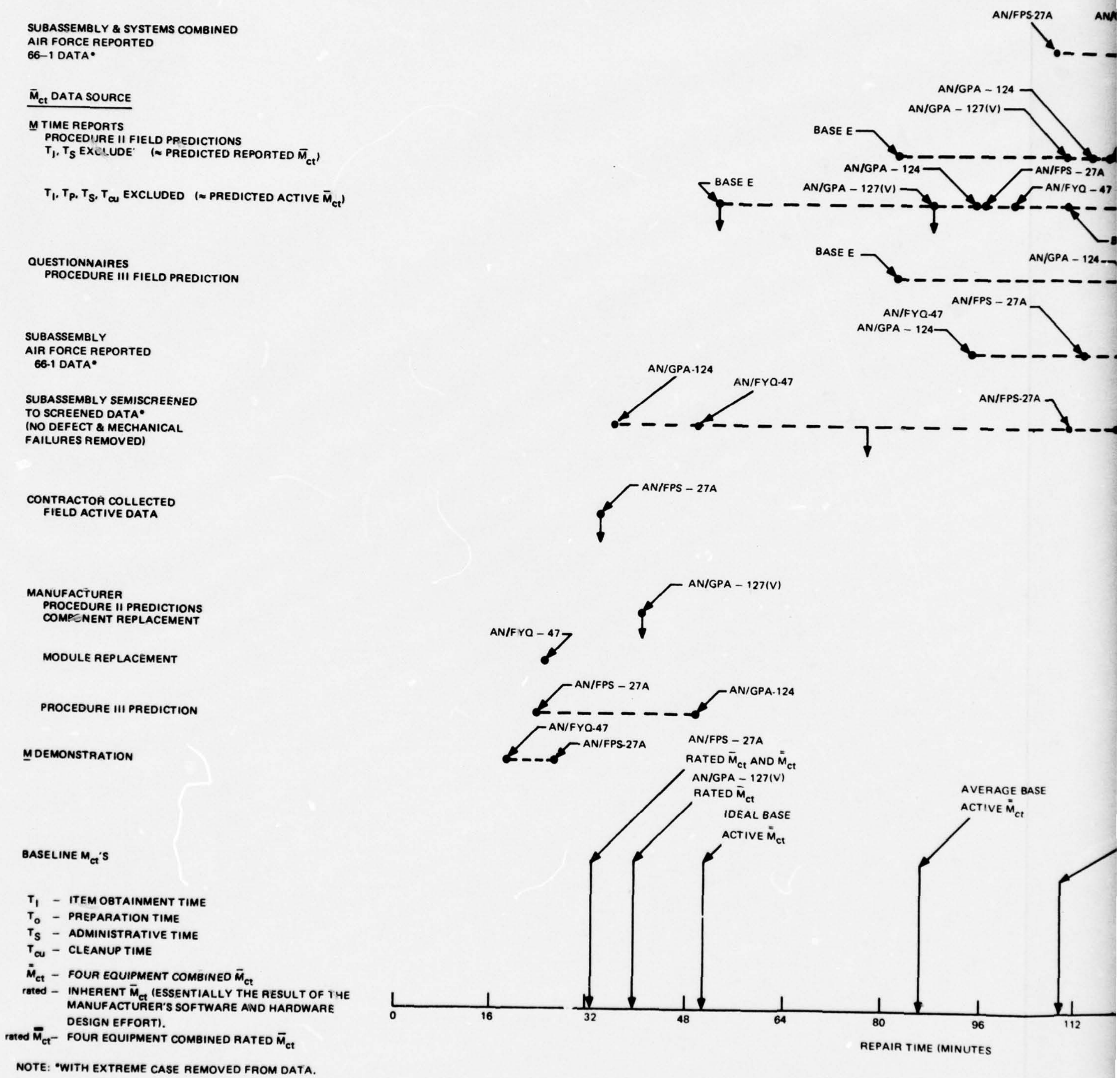

Figure 12. Study Systems Reported or Predicted Avera

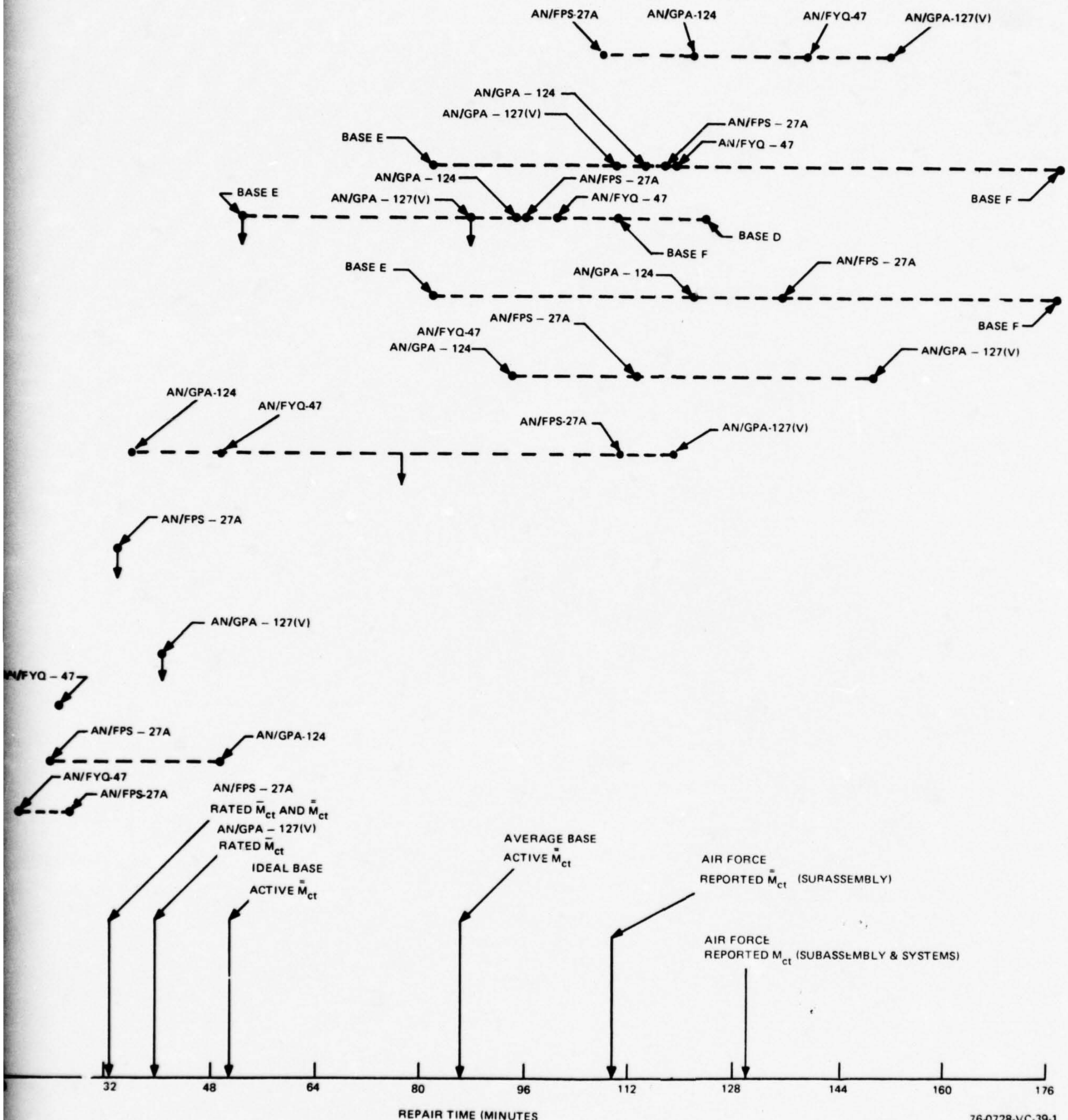

Figure 12. Study Systems Reported or Predicted Average Repair Time Characteristics

2

TABLE 32

BASE/EQUIPMENT DATA VARIABILITY

Data Source	Between Base Variability Δ Time - Minutes	Equipment Variability Δ Time - Minutes
Field Tech. Prediction		
Procedure II	71.25	13.2
Procedure III	95.4	13
Contractor Prediction		
Procedure II	N/A	25.8
Procedure III	N/A	15.2
Air Force		
66-1/65-110	156*	55.2
Demonstration	N/A	8.22

*Includes only the seven bases visited.

affecting field $\underline{M}$, both manufacturer and operational. As illustrated in both figure 12 and table 33, there are several basic factors which account for the differences between inherent M_{ct} and the M_{ct} exhibited at the base with the lowest reported M_{ct}. Factors affecting this difference are repair/support concept differences, proficiency maintenance, and failure reporting policies. Once these factors have been identified, inter-base factors can be determined. These inter-base factors would be those effecting the large quantitative difference between Base E and Base F's reported M_{ct} (figure 12). The major influences affecting this inter-base relationship are:

- Levels of operational spares available.
- Degree of supervised training provided.
- Base climatic conditions experienced.
- Stock room policies employed.
- Amount of administrative time allowed for data reporting.

Once these factors have been identified, the operational factors affecting equipment design/maintenance differences can be identified. Factors significantly impacting this portion of the repair times are:

- Repair/replace concept.
- Training requirements.
- Equipment reliability.
- Equipment usage.
- Depot versus "on-site" repair.

As previously stated, table 33 contains all the influences affecting $\underline{M}$ as identified in this study. Included in this table are the equipments affected by the particular factor, the data source from which the factor was identified, and the relative degree of influence each factor has on the overall field maintainability. Quantitatively, these degrees of influence are as follows:

	very small	$\leq$ 3 minutes
3 minutes	< small	$\leq$ 5 minutes
5 minutes	< medium	$\leq$ 10 minutes
10 minutes	< large	$\leq$ 15 minutes
15 minutes	< very large	

Specific factor identification is given in the following sections.

TABLE 33

FACTORS AFFECTING MAINTAINABILITY (BOTH OPERATIONAL & MANUFACTURERS)

FACTORS	Equipments Affected				Data	Source of Factor				Relative Influence on Reported Field M_{ct}	COMMENTS
	AN/KPA 127	AN/FYQ 47	AN/FPB 27A	AN/KPA 124	Field Prediction	AF Data 66-1 65-110	Contract Collected Data	M-Demo per Mil-Std-471	Other		
I. Manufacturer's Inherent Inaccuracy of Initial Analysis											
A. Inaccurate Repair Weight Weighting (variance in failure rate)	X	X	X	X	X					Very small	Prediction techniques cannot handle mechanical, intermittent, degrading, secondary, and cannot duplicate (CND) failures.
B. Prediction Techniques do not include all possible equipment/component failure modes that can occur. (Based on catastrophic failures only)	X	X	X	X		X	X	X	X	Medium	Repair times in predictions are based on catastrophic failures. Predictive repair times *for degrading, intermittent, secondary and CND's are not included.*
C. Time Lag between Mct prediction and the hardware deployment	X	X	X	X					X	Small	Changes occur in the configuration on which the prediction was based which effects the inherent Mct.
D. Analyst Optimism in assessing maintain ability factors, test features, training and other support functions	X	X	X	X	X	X				Small	Sometimes predictions are made to only satisfy contract requirement. Additionally, if analysis is performed too early in design cycle, test support concepts are not firm.
E. *MIL-STD 472 Predicted Technique Inadequacies*	X	X	X	X					X	Small	Procedure II does not provide a good means for including support functions in analysis (skill level training). Procedure III encompasses support adequately but is too general in areas of specific hardware design analysis.
II. Operational											
A. Maintenance Concept Mismatch (between field practiced and analyst assumed)											
1. Personnel											
Skill level does not comply with planned	X	X	X	X	X					Very small	AF level 5 is assumed in analysis generally and this study showed a slight between base effect. Some bases used level 3 for some maintenance.
Blend of career oriented versus non-career oriented technicians vary	X	X	X	X	X					Very small	No effect between equipments but some between bases (includes circular participation.
2. Spares											
Sparing levels (amounts & level of replacement) as delineated in planned maintenance concept not available.	X	X	X	X	X		X			Medium	In some cases this was caused by a deviation in the actual practiced maintenance concept versus the analyst assumed concept.
Replacement spares not operational.		X	X			X		X		Very small	Field maintenance downtime increased due to failed spare part (not known).
3. Technical Documentation											
Documentation unavailable	X	X	X	X	X					Very small	All bases investigated generally had adequate manual supply for each equipment.
Documentation up to dateness/completeness not finished	X	X	X	X	X			X		Very small	Maintenance manuals did not reflect hardware configurations in a few instances, and in one case did not include specific fault isolation procedures.
4. Support/Test Equipment and Accessorizes											
Special Test Equipment as recommended - not available	X	X	X	X	X					Medium	Some equipmenrs required special "O" scope responses which were not available in general base equipment.
Special hand tools recommended in Technical documentation not available	X	X	X	X	X		X			Large	Special connector crimping, tools, card puller tools, and other accessories not *always available (on the average approximately 60% for all bases).*
5. Training (as it effects proficiency)											
Formal Training as recommended by contractor not conducted	X	X	X	X	X	X	X	X		Very small	Generally, variation in base personnel (over extended period of time) nullifies this if given upon equipment deployment.
Supervised on-site "on equipment" training does not comply with planned concept	X	X	X	X	X	X				Medium	Before technician can exhibit repair proficiency, he must have at minimum 3 weeks supervised "on-equipment" training for operational and maintenance familiarity.
6. System Design Mechanization											
Field level repair as performed c/o lower level than planned, thus making designed-in built-in test equipment inadequare		X		X	X	X				Medium	On many bases, spares are not provisioned to the practiced repair level due to cost of large spares (assemblies vs boards), thus BITE is not as effective as intended.
B. Base Physical Environment (including facilities)											
1. Local lighting not adequate around equipment as well as in large equipment consoles			X	X	X					Very small	Inside equipment cabinets, portable lights should be available for seeing equipment.
2. Physical proximity between various equipment cabinets and the various maintenance resources (test equipment, spares) not close enough.	X				X					Very small	
3. Climatic Conditions degrade equipment inherent maintainability (heat, dust, humidity)	X	X	X		X					Small	Equipment electrical parameters varied due to heat build up causing adjustments actions and CND's. CND s disappeared when cabinet doors opened.
C. General Base Policies											
1. Defective modules (subassemblies & boards) are repaired at the base	X	X		X	X					Medium	When modules are sent to depot, maintenance times per 66-1/65-110 go down.
2. Failures not catastrophic to equipment operation and requiring short Mct times are saved and fixed during periods of extended maintenance (PM)	X	X	X	X	X					Very small	Operational reliability (downtime frequency) is prime base objective and thus *failure grouping helps improve this (on paper).*
3. Failures requiring less than three minutes corrective maintenance time are not recorded	X	X	X	X	X	X	X			Very small	The average Mct is increased since these failures are not recorded as part of the 66-1/65-110 practice.
4. Stockrooms located at some physical distance from equipment require defective parts to be turned in upon requisition of spare.	X	X	X	X	X					Small to Medium	In lieu of filling out all maintenance forms and returning them to base stockroom for each fault, fault isolation to componen (instead of board) is performed.
5. Operational personnel instead of maintenance personnel perform corrective maintenance	X	X	X	X	X	X				Very small	This is done only at certain bases a small portion of the time.
D. Equipment High Reliability											
1. Systems having a low failure rate exhibit higher than expected corrective maintenance times	X	X	X	X		X	X	X		Small to Medium	With low failure rates, "practice" on systems is minimal thus decreasing optimal proficiency.
E. Base Administration											
1. *Preparation and cleanup times are included in field reported Mct.*	X	X	X	X	X	X				Very large	*These times are hard to segregate from the overall field data.*
F. Equipment Design Features											
1. Equipment used as intermediate processors (interfaces between two equipments) exhibits more CND conditions than do prime processing equipment.		X		X		X				Medium	For equipments which process information from other equipments, integrity of data reports must be verified prior to processing. If this isn't done, BIT will detect errors which are not due to hardware failures but software anomolies.

6.1 QUESTIONNAIRE DATA

One method used for determining the various influences affecting $\underline{M}$ in the field environment was to study in detail the questionnaires completed by maintenance personnel at the seven bases visited. Appendix C presents the questions and summarizes the responses.

For each question, certain data is presented. Figure 12 shows Base E to have the lowest $\overline{\overline{M}}_{ct}$ of the bases visited while Base F has the highest $\overline{M}_{ct}$. For this reason the percentage response of each question category is listed for these two bases together with the composite or average seven base response to each question. Similarly the Air Force 66-1 data indicates the AN/GPA-124 to have the lowest $\overline{M}_{ct}$ and the AN/GPA-127(V) the highest. Therefore, for each question, the percentage responses for these two equipments are listed. Additionally, the AN/FYQ-47 and the AN/FPS-27A responses to some questions provided valuable inputs to the development of the inter-equipment factors; thus their percentage responses to each question category are also listed where pertinent. Individual technician's comments are noted where pertinent to the overall study developed.

6.2 MAINTAINABILITY DEMONSTRATION TESTS

As discussed in paragraph 4.4, formal $\underline{M}$ demonstration tests conducted in accordance with MIL-STD-471 test procedures were performed on the AN/FYQ-47 and AN/FPS-27A equipments. The tests were conducted at field operational bases and each simulated maintenance task was performed by Air Force technicians trained and skilled per the equipment maintenance requirements. The $\underline{M}$ demonstrations have proven to be quite valuable in

defining several key operational influences. Table 34 lists each of the five influences determined and the means by which each was found. The demonstration test sample is quite small (51 tasks for the AN/FYQ-47 and 56 for the AN/FPS-27A) and thus a high degree of confidence cannot be placed in the overall weighting of these influences. Also, the tests represent only a two base data sample. However, these factors were easily determined and are considered "real life" since the failure modes occurring in the formal M demonstration test are pre-planned in cognizance with the overall system operational and maintenance concepts. As illustrated in table 35 the three operational factors influencing the AN/FYQ-47 $\overline{M}_{ct}$ averaged 69 minutes 24 seconds, 400% more than the actual demonstrated 17 minutes 47 seconds. On the AN/FPS-27A, all of the simulated maintenance tasks which took longer than 90 minutes were terminated at 90 minutes. The demonstrated $\overline{M}_{ct}$ for this equipment was 27.98 minutes.

During the AN/FPS-27A M Demonstration, some of the simulated tasks - specifically the VGA (refer to table 16) - were repeatedly demonstrated. Figure 13 illustrates a plot of the M_{ct}'s for VGA repairs versus the sequential order of the demonstration. As shown, there is a significant improvement in M_{ct} as the task is repeated, thus depicting the "Learning Curve" pattern.

As shown in table 35, three AN/FPS-27A tasks could not be fixed during the demonstration and thus were deleted from the test report (see table 16). These were attributed to training/proficiency deficiencies. In each case, it was either the first or second time that particular type of task was simulated in the demonstration, this providing additional support of the concept illustrated in figure 13.

From this data, it can be concluded that no matter how well trained technicians are at the end of a formal training period, they will not be totally proficient and may even lose proficiency without practice. Table 34 tabulates the total maintenance data for the four systems under study at the various bases.

TABLE 34

UNSCHEDULED MAINTENANCE ACTION FREQUENCY

Equipment	Total Actions	Time Span	Squadrons Used	Actions Per Squadron Per Month
AN/GPA-127	196	9 Months	20	1.08
AN/FYQ-47	200	9 Months	10	2.22
AN/FPS-27A	120	12 Months	7	1.43
AN/GPA-124	144	12 Months	32	0.38

TABLE 35

OPERATIONAL INFLUENCES DERIVED FROM $\underline{M}$ DEMONSTRATION TESTS

Factor	System	$\underline{M}$ Demo. Task No.	M_{ct}	Comments
1. Defective Spares	AN/FYQ-47	399	45 min 41 sec	During actual demonstration, a spare board was found defective.
2. Technical Manual Up-To Dateness	AN/FYQ-47	440	39 min 30 sec	During the insertion of a fault to be demonstrated (-20VDC EU main power supply), it was found that the technical manual had no fault isolation procedure for this unit. An interium procedure was prepared and used "on-site."
3. *Training*/ Proficiency	AN/FPS-27A	76	>90 min	An A610 Memory Board fault was inserted in channel 5 of the DSP. Memory Board A617 had previously been placed in A610 for a fault isolation correctness check and slot A617 was left empty. Video checks did not reveal any fault correction; however, a closer inspection would have revealed that the original fault was corrected and the incorrect video on channel 6 was due to the missing board in location A617.

Table 35 (Continued)

Factor	System	M Demo. Task No.	M_{ct}	Comments
Training/ Proficiency (cont.)	AN/FPS-27A	88	>90 min	Fault isolation of the DSP was performed to the lower drawer but not to the simulated fault (Integrator Board). The maintenance team checked several test points but failed to manually probe the Integrator test points, thus failing to fault isolate.
	AN/FPS-27A	62	>90 min	After 90 minutes, the maintenance team was unable to fault isolate to the simulated fault (DSP Memory Board).
4. Test Equipment	AN/FPS-27A	07	>90 min	During fault isolation, the SLB Board (Stalo Power Amplifier) was removed and replaced with an extender board. A check of the SLB Board indicated a fault. After 90 minutes of analysis, the task was abandoned and subsequently the extender board was determined faulty thus causing the SLB Board to appear defective.

Table 35 (Continued)

Factor	System	M Demo. Task No.	M_{ct}	Comments
5. Multiple Failures	AN/FYQ-47	444	123 min	While performing a fault isolation of the +20VDC EU power supply, a fault occurred in the +30VDC sub unit power supply. This additional failure occurred independently of the first +20VDC simulated fault but created two simultaneous faults.

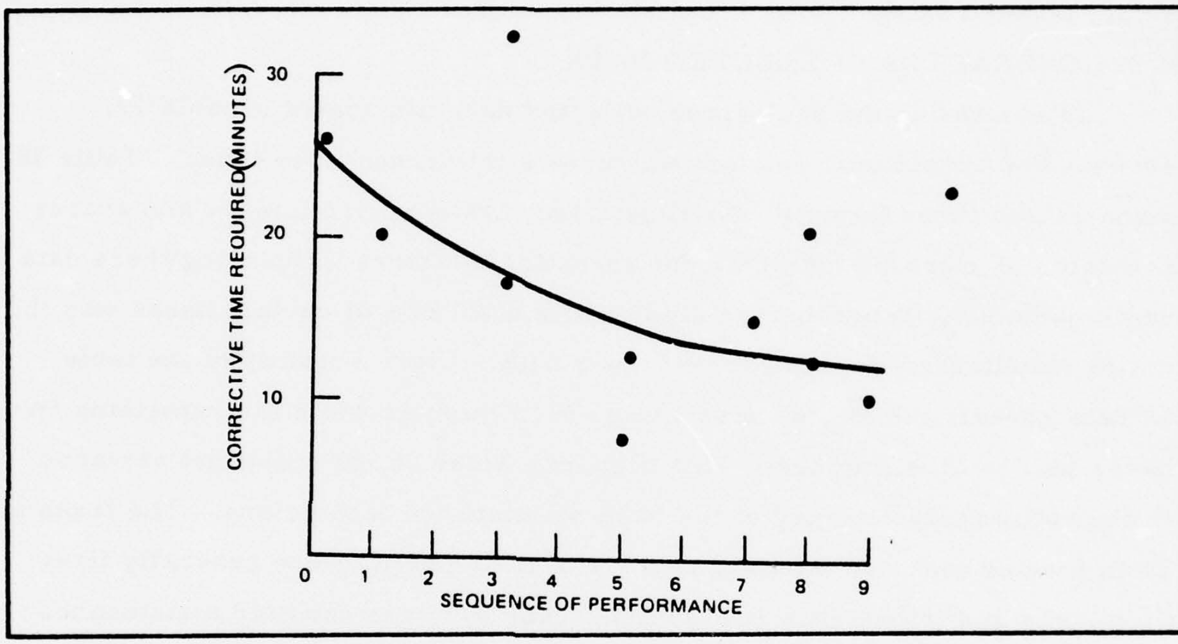

Figure 13. AN/FPA-27A VGA Demonstration Data

As shown, the monthly average frequency of repairs varies from 2.22 actions per month for the AN/FYQ-47 to 0.38 for the AN/GPA-124.

From this data, it is concluded that "rustiness" is a field "operational influence" since the field personnel do not have frequent opportunities to retain learned skills.

6.3 CONTRACTOR COLLECTED DATA

In evaluating the contractor collected data illustrated in table 19, several key operational and manufacturer's influences were found. Table 36 summarizes these factors. As illustrated, training/proficiency and spares provisioning were the predominent operational factors influencing these data while variability between predicted and field MTBF's at certain bases was the major manufacturers influence on these data. Close scrutiny of the table 19 data reveals the $\overline{M}_{ct}$ of Base I to be 51.3 minutes while the remaining five bases' $\overline{M}_{ct}$ is 21.4 minutes. This disparity alone shows a distinct variance in the training/proficiency of the base maintenance technicians. The tasks at Base I which took the extended periods of time ($\gg \overline{M}_{ct}$) were generally first time tasks and in one case (RF switch, Task #17) was the only maintenance task of that type to occur as part of the data base at any of the operational bases. A second operational influence was the inadequacy of spare part provisioning, particularly at base H. An unusual amount of RF amplifier failures at this base caused an on-base shortage of replaceable spares. More specifically, this shortage of spares was attributed to a combination of two factors:

- Operational and/or maintenance errors cause failures (training problem).
- A mismatch between the AN/FPS-27A predicted failure rate distribution and the actual field failure distribution.

Referring to the data (table 19), the "operational/maintenance error attributed to training" factor is the predominent influence of the two described since in all the other field collected data ($\underline{M}$ demonstration, field collected per AFM 66-1, and contractor collected data), the actual field equipment failure

TABLE 36

CONTRACTOR COLLECTED DATA INFLUENCES
(AN/FPS-27A)

Factor	Task No.	Base	M_{ct}	Comments
1. Training/ Proficiency	15	I	59	$M_{ct} >> \bar{M}_{ct}$ due to "first time" failure occurrence.
	16	I	41	
	17	I	145	
	19	I	42	
	5	H	32	Maintenance induced during installation.
	7	H	18	
	13	H	21	
2. Spare Part Provisioning	5	H	22	Long logistic delay times in addition to M_{ct} due to lack of spare parts.
	7	H	18	
	13	H	21	
	17	I	145	
3. Manufacturers' Predicted and Field Failure Rate Distribution Mismatch	5	H	22	Logistic delay caused by unanticipated failures. Field failure distribution is different from predicted failure distribution.
	7	H	18	
	13	H	21	
	17	I	145	

distribution on the AN/FPS-27A is not as biased toward RF Amplifier failure as that of Base H. However, again referring to the data, the RF amplifier failed once each at Bases I and J. Thus, there is a slight disparity between predicted and field failure distribution but not as significant as that indicated by the Base H data.

Failure #17 (table 19, RF Switch) is an example which combines each of the above three mentioned influences (training/proficiency, spares provisioning inadequacy, predicted and demonstrated failure distribution mismatch) in that 145 minutes ($\overline{M}_{ct}$ = 27.98 minutes) were needed to isolate and correct the problem. No spare was available for replacement upon system failure. This failure occurred once out of 21 tasks for a λ = 4.76%. The predicted λ for the RF Switch is less than 0.5% of the total AN/FPS-27A failure rate.

6.4 AIR FORCE DATA

As discussed in Section 4.1, 66-1/65-110 data were collected and analyzed for all the systems studied for up to 32 squadrons. Table 7 summarizes this data. As illustrated in this table, Air Force corrective maintenance data has been divided into three major categories:

- Subassembly data with crew size.
- System data with crew size.
- Data without crew size.

Evaluation of each of these categories has determined some field operational influences on maintainability. The following paragraphs discuss this evaluation.

6.4.1 Subassembly Data with Crew Size

Table 37 summarizes the subassembly data with crew size. This data more closely matches the analytical prediction data provided by the equipment manufacturers in that each reported field corrective maintenance action is scored against a system's individual subassembly. Additionally, the crew size has been determined and thus compliance and/or violation

TABLE 37

AIR FORCE SUBASSEMBLY DATA WITH CREW SIZE

	Semiscreened Data		No Defects				Mechanical Repair				Extreme Cases				Administrative Times	Screened Data				M_{ct} (Hrs.)
	No. of Events	M_{ct} (Hrs.)	No. of Events	%	M_{ct} (Hrs.)	%	No. of Events	%	M_{ct} (Hrs.)	%	No. of Events	%	M_{ct} (Hrs.)	%	(Hrs)	No. of Events	%	M_{ct} (Hrs.)	%	
AN/GPA-127(V)	142	351.3	8	5.6	9.1	2.59	8	5.6	71.9	20.5					21	126	88.7	249.3	71	1.98
AN/FYQ-47	170	344.8	33	19.4	128.9	37.4	1	0.6	2.7	0.8	1	0.6	83.8	24.3	22.5	135	79.4	106.9	31	0.79
AN/FPS-27A	90	167.4	12	13.3	10.7	6.39									13	78	86.7	145.4	86.9	1.86
AN/GPA-124	71	110.1	3	4.2	55.1	50									9.2	68	95.8	45.8	41.6	0.67
Totals	473	973.6	56	11.8	203.8	20.9	9	1.9	74.6	7.66	1	0.2	83.8	8.6	65.7	407	86	547.4	56.2	1.34

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of the system's designed maintenance concept can, in part, be determined. As shown, four basic categories were separated out of the semiscreened data: no defects, mechanical repair, extreme cases, and administrative times. No defects totaled 11.8% of the total corrective maintenance actions performed on these four systems and 20.9% of the M_{ct}. These no defects are primarily caused by two factors:

- Erroneous input data to any of the systems from other equipment (does not apply to the AN/FPS-27A) not verified by BITE prior to processing, and thus contributing to error processing and equipment fault indication.
- Inadequate training contributing to excessive and unnecessary fault isolation times when a fault (actually false alarm) is indicated.

If the systems would provide a test data pattern generator to periodically verify input data integrity, in particular when a failure is reported, false alarms could be checked prior to corrective maintenance thus minimizing the reported no defects. As shown in table 37, the AN/FYQ-47 (37.4%) and the AN/GPA-124 (50%) have an excessive amount of no defects M_{ct} attributed to verifying the no-defects condition, again confirming the need for a more comprehensive BITE scheme and training program.

Another factor, failure mode mismatch, is highlighted in mechanical repairs. The AN/GPA-127(V)'s gear train wear-out mechanism is clearly presented (8 instances with a $\overline{M}_{ct}$ of 9 hours each).

The long repair instant (83.8 hours) illustrated under the AN/FYQ-47 extremes case cumulates several factors:

- Inadequate training.
- Multiple failures.
- Maintenance concept mismatch.
- System inadequate BITE.

Once the influences described above have been filtered out of the semiscreened data, an $\overline{M}_{ct}$ results. The AN/GPA-124 $\overline{M}_{ct}$ has the lowest reported filtered $\overline{M}_{ct}$ while the AN/GPA-127(V) has the highest. The reason for this

lies in maintenance concept differences. Specifically, the AN/GPA-124 affords board replacement while the AN/GPA-127(V) reported M_{ct}'s are based on on -line part repair.

6.4.2 System Data With Crew Size

Referring to table 7, 23% of the total field reported corrective maintenance actions were system failures with an assigned crew size. The $\overline{M}_{ct}$ for these actions was 2.6 hours. General factors attributing to these excessive $\overline{M}_{ct}$'s were

- Multiple failures.
- Maintenance concept mismatch.
- Inadequate training.
- Inadequate fault isolation techniques.

The multiple failure occurrence can primarily be broken down into two basic categories: secondary failures caused by a primary system failure, and the accumulation of failures which had little effect on system overall operation for one system's recorded maintenance action. Data showed that this latter condition was more prevelant, especially in the AN/FPS-27A which has a ten beam receiver processor, of which only eight are required. In this, failures in any one of the ten receiver channels can be tolerated without affecting system operation, until a system catastrophic failure occurs. These "soft" failures are fixed either in periods of preventative maintenance or during the maintenance of catastrophic failures. The remaining three factors were hard to separate out in this data. Generally, when failures occurred in the AN/GPA-124 and the AN/FYQ-47, it was difficult to fault isolate to a replaceable board via BITE or external test equipment. This was atrributed to either inadequate training or inadequate fault isolation factors; however, in the case of the AN/FYQ-47, the maintenance concept mismatch factor helps contribute to this condition. As discussed in Section 3, the maintenance concept for the AN/FYQ-47 consisted of fault isolation to a faulty board by replacing boards in the system with known "good" boards in a predetermined sequential manner.

This maintenance concept was generally not followed by the various squadrons, thus causing fault isolation to be longer than expected and scattered throughout the various major assemblies. The large (50.1%) number of AN/GPA-124 system recorded field corrective maintenance actions can be attributed directly to the ambiguous fault isolation techniques utilized and the inadequate degree of formal training which compounds fault isolation problems.

6.4.3 Data Without Crew Size

As illustrated in table 7, 5.3% of the total Air Force data did not have an accountable crew size. This could be attributed to inadequate reporting by squadron personnel and/or transcribing errors during reduction of this data to either the 66-1 or 65-110 format. In either case, the amount is insignificant (5.3%) and if the standard crew of two were employed, the data would correlate with the subassembly data and the operational factors would also be similar.

Equipment	Subassembly $\overline{M}_{ct}$ (crew size known)	Unknown Crew Size (Assume 2)
AN/GPA-127(V)	2.47	2.35
AN/FYQ-47	2.02	1.91
AN/FPS-27A	1.86	1.00
AN/GPA-124	1.55	0

7. MATHEMATICAL MODEL

7.0 General

This section provides a mathematical model for converting manufacturer's predicted MTTR to Air Force reported field maintenance time as reported in the Air Force data collection system. The mathematical model was heuristically derived based on the various data elements described in Section 4 for the four systems studied. The model, as illustrated in figure 14 is a two multiplier Z adjustment model:

$$\left\{\begin{array}{c}\text{Air Force}\\ \text{Field Reported}\\ M_{ct}\end{array}\right\} = [Z_1] \quad [Z_2] \left\{\begin{array}{c}\text{Manufacturer's}\\ \text{Predicted}\\ \text{MTTR}\end{array}\right\}$$

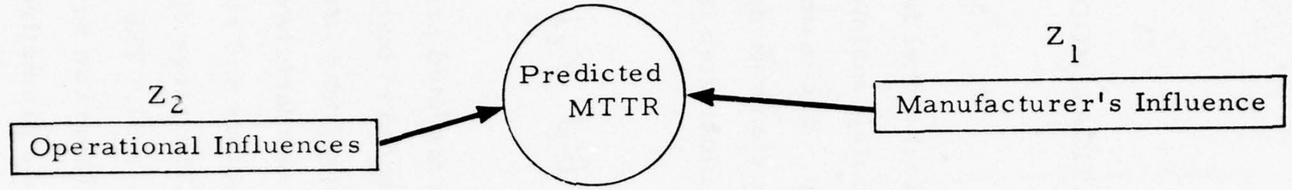
The first multiplier factor, Z_1, is directed primarily at manufacturer type factors. Prediction inaccuracies attributed to inaccurate repair rate weighting and unaccountable for failure modes comprise a major portion of this influence. Additional factors contributing to this manufacturer variability are analyst optimism/pessimism in assessing $\underline{M}$ factors and system configuration changes occurring subsequent to the analysis. The range of the Z_1 factor based on the data used in this study is 0.67 to 1.87. The average Z_1 for these data is 1.20. This 1.20 Z_1 multiplier value can be interpreted as a general verification of the integrity of the various predictive techniques used in this study.

The Z_2 multiplying factor deals with the adjustments required to compensate solely for the field operational influences on $\underline{M}$ and its range varies from 0.66 to 10.00. On the average Z_2 for the equipment studied in the analysis is 3.78. Six major influences comprise the Z_2 multiplier:

FIGURE 14

Mathematical Model For
Influences on Maintainability

Air Force Field Reported M_{ct} $= Z_1 Z_2$ [Manufacturer's Predicted MTTR]



- Maintenance Concept Mismatch
- Base Physical Environment
- General Base Policies
- Equipment Reliability
- Base Administration Policies
- Equipment Design Features

- Inaccurate Repair Rate Weight
- Unaccountable for Failure Modes
- Configuration Changes
- Analyst Optimism/Pessimism
- Prediction Technique Inadequacies

- Maintenance concept mismatch between field practiced and analyst predicted.
- Inter-base variation in overall physical environments such as lighting, climatic conditions and prime/support equipment proximity.
- Inter-base variation in overall base operating and maintenance support policies such as on-site versus depot repair, failure reporting procedures. stockroom policies, and maintenance personnel qualifications.
- Equipment reliability and how it effects maintenance proficiency.
- Inter-base administration policies and how they effect maintenance preparation, cleanup, and failure reporting times.
- Variation between equipment design features causing such problems as can-not-duplicate failures.

Table 38 summarizes both the manufacturers and operational influences and provides the relative weighting for each factor. Also illustrated in this table are the typical (average) contribution values for each factor identified as part of this study.

As exhibited in the table, unaccountable for failure modes and prediction technique inadequacies have the largest potential effect on the manufacturer's MTTR growth. However, referring to the typical values listed, on the average each of the manufacturer's identified influences have a relatively small effect on the overall MTTR growth.

Referring to the operational influences, the maintenance concept mismatch and the general base policies provide the potentially largest quantitative influence on the field MTTR growth. Primary factors driving these influences are the lack of support/test equipment and accessories (specifically special hand tools and special test equipment), spare part provisioning (part and not sub-assembly as generally assumed in maintenance concept) and general base stockroom policies. Each of these factors have been discussed in Section 6.

Additional significant influences are base administration, equipment design features, and the drop in maintenance proficiency attributed to the high equipment reliability. All of the other influences also contribute to the MTTR growth

TABLE 38

Maintainability Influences and Their

Relative Weighting

Factor	Range of Influence	Typical Degree of Influence
I. Manufacturer	0.67 - 1.87	1.20
A. Inaccurate Repair Rate Weight	1.00 - 1.09	1
B. Unaccountable for Failure Modes	1.00 - 1.19	1
C. Configuration Changes Not Included in Prediction	1.00 - 1.09	1.1
D. Analyst Optimism/Pessimism	1.00 - 1.08	1.09
E. Prediction Technique Inadequacies	0.67 - 1.23	1.0
II. Operational	0.66 - 10.00	3.78
A. Maintenance Concept Mismatch	1.05 - 3.34	2.16
1. Personnel	1.00 - 1.15	1.15
2. Spares	0.89 - 1.43	1.21
3. Technical Documentation	1.00 - 1.13	1.06
4. Support/Test Equipment and Accessories	1.18 - 1.56	1.39
5. Training	1.00 - 1.07	1.00
6. System Design Mechanization	1.00 - 1.11	1.06
B. Base Physical Environment	0.97 - 1.12	1.06
1. Lighting	1.00 - 1.03	1.03
2. Physical Proximity	0.97 - 1.03	1.00
3. Climatic Conditions	1.00 - 1.05	1.03
C. General Base Policies	0.98 - 1.28	1.17
1. Base versus Depot Repair	1.00 - 1.17	1.10
2. Failures fixed in Preventive Maintenance Periods	0.98 - 1.00	1.00
3. Non-Recorded Maintenance Actions	1.00 - 1.04	1.04
4. Stockroom	1.00 - 1.03	1.00
5. Operational Personnel Performing Maintenance	1.00 - 1.02	1.02

TABLE 38 (Continued)

Factor	Range of Influence	Typical Degree of Influence
D. Equipment Reliability	1.02 - 1.10	1.06
E. Base Administration	1.11 - 1.28	1.22
F. Equipment Design Features	0.58 - 1.44	1.09
1. Could Not Duplicate Failures	0.58 - 1.03	1.00
2. Interface Characteristics	1.00 - 1.40	1.09

problem; however, their degree of contribution is not significant enough to highlight in this discussion since they are shown in the table.

In summary the overall possible variation in the product of $[Z_1 \ Z_2]$ is 0.44 to 18.70. However, typically the $[Z_1 \ Z_2]$ product is 4.54 which simply states that if an equipment MTTR prediction is 30 minutes, the expected field corrective maintenance time would be 136.2 minutes or 2 hours and 16 minutes.

7.1 Utilization

As previously stated, the mathematical model depicted in paragraph 7.0 has been designed to translate an equipment's predicted MTTR into the field's experienced M_{ct}. This conversion is required primarily for logistics planning purposes, i.e., off-line repair time requirements, initial and pipeline spare part requirements, and personnel requirement with regards to qualifications, special training, and number. In order to arrive at the Z factors required for MTTR translation, a checklist based on the factors identified in table 33 and their relative degree of influence has been derived. This checklist is illustrated in table 39. In making the field M_{ct} estimation, this checklist must be completed. Two numerical values will be derived from this analysis; a value based on manufacturer's influences (S1), and a second value based on field operational influences (S2). These quantitative estimates must then be converted into their respective Z multipliers. Table 40 provides the algorithms required for this conversion. As shown in table 40, only the score from the manufacturer's checklist (S1) is required for the Z_1 computation; however, when deriving Z_2, both the scores from the operational part of the checklist (S2) as well as S, must be employed. Once the individual Z_1 and Z_2 multiplier factors have been determined, the mathematical model utilized in paragraph 7.0 is utilized to make the conversion from predicted MTTR to field M_{ct}. Also illustrated in table 40 are the maximum and minimum scores that theoretically can be obtained from the checklist. Using these scores and the respective algorithms, the field experienced M_{ct} for an equipment whose MTTR is 30 minutes can range from 13 minutes (which is highly unlikely) to a maximum of 561 minutes or 9 hours and 21 minutes. It should be stated that these extreme values (13 minutes and 561 minutes represent only theoretical conditions in that for an equipment to attain these values, all influences (table 33) must be completely one sided (either extremely good or bad) and thus not representative of the average or standard equipment deployment and operational/maintenance scenario.

TABLE 39

MANUFACTURER/OPERATIONAL INFLUENCE CHECKLIST

Factor		Score
I Manufacturer's Inherent Inaccuracy of Initial Analysis		
A. Inaccurate Repair Rate Weighting		
1. Does the equipment contain mechanical parts that are susceptible to wear-out, i.e., motors, gear trains.	Yes	1
	No	0
2. Does the equipment use proven technology in design or does it use some advanced state of the art design.	Advanced	1
	None	0
3. Do the predicted failure rates reflect actual usage conditions (actual electrical, thermal, vibrational stress conditions as opposed to nominal conditions).	Yes	0
	No	1
B. Reliability Prediction Techniques do not include all possible equipment/component failure modes that can occur.		
1. Does the equipment contain mechanical parts subject to wear-out.	Yes	2
	No	0
2. If the design is advanced state-of-art, are all component failure modes known and incorporated in analysis.	Yes	0
	No	5
C. Is there a significant calendar time lag between the final MTTR analysis and the actual deployment in the field (thus allowing for configuration changes not incorporated in analysis).	Yes	3
	No	0
D. Has the analysis been performed early in system design such that optimism in assessing maintainability, factors percipitates throughout the accessibility, test, training and other support functions.	Yes	3
	No	0
E. What technique was utilized in making the MTTR analysis.	Demonstration	+10
	Procedure II	0
	Procedure III	-10 to +10
	(a) early design	-10
	(b) final config.	+10

II. Operational Influences

A. Maintenance Concept Mismatch (difference between field practiced and analyst assumed)

1. Personnel

(a) Does the average maintenance personnel skill level comply with that planned.	Yes No	0 3
(b) Are more than 10% of the maintenance technicians non-career oriented.	Yes No	2 0

2. Spares

(a) Are sparing levels, especially boards and subassemblies as delineated in the planned maintenance concept.	Better than Planned Less than	-4 ±6 +16
(b) Are special measures being taken to assure that replacement spare parts (especially boards, subassemblies) are 100% operational.	Yes No	0 1

3. Technical Documentation

(a) Is enough technical documentation being supplies to equipment user such that all maintenance technicians have immediate access to them for use.	Yes Sometimes No	0 1 2
(b) Does technical documentation reflect configuration of equipment being used.	Yes Sometimes No	0 2 4

4. Support/Test Equipment and Accessories

(a) Is the electrical test equipment recommended in the technical documentation available to the maintenance technician for use.	Yes Sometimes No	3 9 15
(b) Are the special hand tools and accessories recommended in the technical documentation availabl e for maintenance technician use.	Yes Sometimes Seldom	8 10 12

5. Training		
(a) Is the formal (classroom) training recommended by the equipment supplier carried out by the user.	Yes No	0 2
(b) Is supervised on-site equipment training performed as recommended by contractor.	Yes No	0 +5
6. System Design Mechanization		
(a) Is field repair performed to a lower level than planned thus making designed in maintainability features (especially BITE) inadequate.	Yes Sometimes No	8 4 0
B. Base Physical Environment (including facilities)		
1. Is local lighting around equipment and inside where appropriate adequate to perform maintenance.	Yes No	0 2
2. Is the physical proximity between the various equipments and the maintenance resources (test equipment, spares, etc) sufficiently close to avoid delay in maintenance.	Yes Sometimes No	-2 0 +2
3. Is the local climatic conditions (temperature, vibration, humidity) the equipments design limitations are being environmentally exceeded.	Yes Sometimes No	4 2 0
C. General Base Policies		
1. Are failed boards and/or subassemblies repaired at the operating base (as opposed to being sent to a depot).	No Sometimes Most of time Always	0 4 8 12
2. Are non-catastrophic failures ignored and fixed only in periods of scheduled maintenance.	Seldom Often	0 -1
3. Are failures requiring less than three minutes for corrective maintenance recorded as part of the Air Force maintenance reporting system.	Seldom Often	3 0

4. Do stockrooms remotely located from the equipment require defective components/assemblies to be turned in upon requisition of a spare.

No	0
Yes	3

5. Do operational rather than trained maintenance personnel perform the required equipment corrective maintenance.

Sometimes	2
Never	0

D. Equipment Reliability

1. What is the field failure rate at a base of the operational equipment.

$\lambda < 5$ f/mo	8
5 f/mo $\lambda < 10$ f/mo	5
$\lambda > 10$ f/mo	2

E. Base Administration

1. Preparation and **clean**-up times are included in the field reported M_{ct}.

Yes	25
Sometimes	20
No	15

F. Operational Effect on Equipment Design Features

1. Are can-not-duplicate failures included in as part of the reported corrective maintenance time.

(a) Digital Equipment	Yes	0
	No	-40
(b) Analog Equipment	Yes	0
	No	+3

2. Are system failures (not one component only) a significant portion of the anticipated field corrective maintenance actions (interface problems).

(a) Digital Equipment	Significantly	40
	Moderately	20
	None	0
(b) Analog Equipment	Significantly	8
	Moderately	4
	None	0

TABLE 40

MTTR/M_{ct} (FIELD) ALGORITHMS AND ASSOCIATED DATA

	S_1	S_2	Z_1	Z_2
Maximum	+26	+180	1.87	10
Minimum	-10	- 19	0.67	0.66

$$Z_1 = \frac{30 + S_1}{30} \qquad Z_{1\,\substack{\text{Max}\\\text{Min}}} = \frac{30 + S_{1\,\substack{\text{Max}\\\text{Min}}}}{30}$$

$$Z_2 = \frac{S_1 + S_2 + 30}{S_1 + 30} \qquad Z_{2\,\substack{\text{Max}\\\text{Min}}} = \frac{S_{1\,\substack{\text{Min}\\\text{Max}}} + S_{2\,\substack{\text{Max}\\\text{Min}}} + 30}{S_{1\,\substack{\text{Min}\\\text{Max}}} + 30}$$

Note:

When deriving Z_2 maximum, the S_2 max and S_1 min scores must be used, and when deriving Z_2 minimum, the S_2 min and S_1 max scores must be used.

It should also be noted that with this checklist and the model, one can convert an MTTR demonstrated in a formal MIL-STD-471 Maintainability Demonstration Test into a field M_{ct} by simply making the proper response to question I. E. of the checklist and then proceed normally with the calculation of Z_1 and Z_2 and insert the demonstrated MTTR into the model in place of the predicted MTTR. Also, it should be noted that question I. E. distinguishes the difference between MIL-HDBK-472 Procedure II and III's relative degree of accuracy.

It should be noted that also included in Table 39 are typical responses to the checklist questions. These typical values are based on the average answer for the equipments evaluated in this study, and are the underlined number in Table 39. Thus, if when evaluating any ground electronic equipment with this checklist, and an answer can not be determined, then the typical value for that response should be utilized.

The following illustrates the use of the Mathematical model on the four equipments studied in this contract. Table 41 summarizes the checklist parameter for the four equipments for the MTTR/M_{ct} conversion. Using these S_1 and S_2 values in the Z_1 and Z_2 formula, the quantitative values for Z_1 and Z_2 were calculated. Using these factors, the equivalent MTTR/M_{ct} (field) multiplying factor was calculated. Table 42 summarizes these results, that is the predicted MTTR's, the Z_1, Z_2 and Z_1Z_2 values for each of the equipments (based on the checklist evaluation), the predicted field M_{ct} based on the derived mathematical model, and finally the actual average field reported M_{ct}'s for the equipments studied. As can be seen the calculated field $\overline{M}_{ct}$ for both the AN/FYQ-47 and AN/FPS-27A equipments are accurate to within -14% and -12% of the actual field reported $\overline{M}_{ct}$ (via 66-1/65-110). However, for the AN/GPA-127(V), there is a +17% error and for the AN/GPA-124 a +37% error. For these two equipments, a correction formula had to be applied to account for some of the anomolies built into the data which becomes apparent when the predicted MTTR is either greater or less than 25% of 30 minutes. In general, when the predicted MTTR is too high (>>30 minutes), the Z_1 Z_2 estimates

TABLE 41

CHECKLIST EQUIPMENT EVALUATION

Checklist Item	AN/GPA-127	AN/FYQ-47	AN/FPS-27A	AN/GPA-124
I.				
A.				
1.	1	0	0	0
2.	0	0	0	0
3.	0	0	0	0
B. 1.	2	0	0	0
2.	0	0	0	0
C.	3	3	3	3
D.	3	3	3	3
E.	0	0	+10	-10
II.				
A.				
1. a.	3	3	3	3
b.	2	2	2	2
2. a.	16	-4	6	-4
b.	1	1	1	1
3. a.	2	1	1	0
b.	2	2	2	2
4. a.	3	9	9	9
b.	10	10	10	8
5. a.	2	0	0	0
b.	3	0	0	0
6. a.	4	4	4	4
B. 1.	2	2	2	0
2.	0	0	0	-2
3.	0	2	2	2
C. 1.	12	12	8	0
2.	0	0	0	0
3.	3	3	3	3
4.	3	0	0	0
5.	2	2	2	2
D. 1.	2	2	5	5
E. 1.	20	20	20	20
F. 1. a.	N/A	0	N/A	0
b.	0	N/A	0	N/A
2. a.	N/A	40	N/A	20
b.	0	N/A	0	N/A

TABLE 42

MTTR/M_{ct} (PREDICTED AND FIELD) SUMMARY

Equipment	AN/GPA-127(V)	AN/FYQ-47	AN/FPS-27A	AN/GPA-124
Predicted MTTR (min)	39.5	24.32	23	48.8
S_1 Value	9	6	16	-4
S_2 Value	92	111	80	75
Z_1 Value	1.3	1.2	1.53	0.87
Z_2 Value	3.36	4.08	2.74	3.89
Z_1 Z_2	4.43	4.90	4.19	3.38
Predicted field $\overline{M}_{ct}$	172.5	118.97	96.42	165.2
*Actual field (min) Reported $\overline{M}_{ct}$	149.6	138.24	108.96	120.5
% Error	+15%	-14%	-12%	+37%
Corrected field $\overline{M}_{ct}$ (min)	131	N/A	N/A	101

*Data derived from figure 12. Includes all 66-1 data except the "No-Crew Size" data as also listed in table 7.

will be higher than expected, and when the predicted MTTR is too low (<< 30 minutes) the $Z_1 Z_2$ estimates will be too low. Thus, the following holds:

(1) 22 minutes $\leq$ MTTR (predicted) $\leq$ 38 minutes

Field expected $\overline{M}_{ct} = Z_1 Z_2$ MTTR

(2) 22 minutes > MTTR (predicted) > 38 minutes

Field expected $\overline{M}_{ct} = Z_1 Z_2$ (F) MTTR

where

$$F = \frac{1}{1 + \frac{\text{MTTR (predicted)} - 30}{30}}$$

Simplifying the latter equation

$$\overline{M}_{ct} \text{ (field)} = Z_1 Z_2 \text{ (F) MTTR}$$

$$\overline{M}_{ct} \text{ (field)} = 30 + S_1 + S_2$$

which can be utilized directly in place of the original proposed model when

22 minutes > MTTR (predicted) > 38 minutes

7.2 MODEL DERIVATION

The mathematical model derived in section 7.0 was derived in a two step approach. The first step consisted of utilizing figure 12. From this illustration the factors and their relative weights which "grew" the predicted MTTR's of the various equipments studied to the Air Force reported corrective maintenance times were derived. This took six basic steps. Once these factors and their various weights were identified it was noticed that many of the same factors were the cause for more than one of the growth steps. Thus, the second step of the analysis consisted of consolidating all of the factors into the recommended two multiplier model.

7.2.1 Step One

This paragraph describes the method in which the quantitative relationship between predicted MTTR and Air Force reported corrective maintenance time was determined. Figure 12 was the key to the entire quantitative evaluation. Referring to this figure, it is noted that the average reported field M_{ct}'s for the equipments studied are approximately 4.54 times larger thanthe predicted MTTR's thus lending to the multiplier approach.

The first step in evaluating figure 12 lies in utilizing the contractor collected data provided by the AN/FPS-27A data collection program. The 32.3 minute $\bar{M}_{ct}$ was used as the initial point of departure since:

- It reflects actual field maintenance performed by Air Force field technicians
- It reflects purified data collected under contractor control in that the operational influences have been filtered out.

This data relates closely to the demonstrated and predicted MTTR's for the AN/FPS-27A, 26.1 minutes and 23 minutes respectively, and is considered the inherent field MTTR for the equipment. However, some adjustment between predicted and contractor collected field data was made to account for the prediction inaccuracies. These adjustments (deviation from a multiplier of 1) and their degree of influence are summarized in Table 43. These degrees of influence are given in terms of minutes. An average multiplying factor of 1.20 was determined as the average manufacturer's influence. This was arrived at as follows:

$$\text{Degree of Manufacturer's Influence} = \frac{\sum_{i=1}^{5} \frac{32.3}{MTTRi}}{5}$$

where MTTRi is the predicted and demonstrated MTTR's for the AN/FPS-27A, AN/FYQ-47 and the AN/GPA-124 equipments. The AN/GPA-127's predicted MTTR was not included in this evaluation since (1) it's design contained some influencial mechanical parts which skewed its anticipated field failure rate distribution and (2) its field repair concept was peculiar to the other equipments in that is was component instead of board replacement. By excluding this equipment from the calculation, the number reflected in the manufacturer's influences represent a homogeneous mixture of equipment design and support concepts. This AN/GPA-127 influence due to the design and support differences will be accounted for in the operational influence calculation.

As illustrated in table 43, manufacturer's factors (3) and (4) contribute most significantly to the manufacturer's influences. These factors which were arrived at from the discussions in section 6 were determined primarily

TABLE 43

MANUFACTURER (Z_1) INFLUENCIAL FACTORS AND RELATIVE WEIGHTS

Factor	Range of Influence (minutes)	Typical Degree of Influence
1. Inaccurate Repair Rate Weights	0 - 3	0
2. Unaccountable for Failure Modes	0 - 7	0
3. Configuration Changes Not Included in Prediction	0 - 3	3
4. Analyst Optimism/Pessimism	0 - 3	3
5. Prediction Technique Inadequacies	-10 - +10	0
Composite	-10 - +26	+6

through the field technicians responses to the questionaires. Deviations in configuration were determined via the errors in the system software, i.e., technical documentation, also determined through the field visits.

The degree of analyst misjudgement was determined by looking at the actual contractor collected data and correlating this with the various predictive assumptions. Again, there was some degree of optimism, but not a large degree. "Unaccountable for Failure Modes" potentially can have a significant impact on the manufacturer's factors, but overall it had no noticeable effect in this study. Factors that would contribute significantly to this would be mechanical failures; however, since in majority the systems studied are electrical, this factor had neglectible effect. Prediction Technique Inadequacies also has a small effect generally attributed to the universal nature of the predictive technique. However, again the impact was neglectable on the manufacturer's influences. Finally, repair rate weights (λ) could possible effect the MTTR/field M_{ct} relationship; however, the data used in this study showed no effect.

The next five steps deal with adjustments required to compensate solely for the field operational influences on maintainability. The potential composite range of influence for these five steps can vary from 0.66 to 10.00; however, on the average this figure of merit is 3.78. This range was determined by taking all the factors contributing to this operational influence, normalizing their degree of relative contribution with respect to each other, noting the different degree of contribution both between equipments and between bases, and finally making a composite listing of these factors and their relative degree of influence. As illustrated above, some factors at some bases can have a positive effect on the MTTR (multiplying factor less than one); however, on the average this is not true(3.78).

The initial step in determining the operational factors was to first determine the differences between Base E (which is considered the ideal base) and the contractor collected data (32.3 minutes). Base E is considered the ideal base since it has the lowest field reported $\bar{M}_{ct}$ (see figure 12).

In the field, the majority of faulty circuits and assemblies are repaired on base. For an ideal base, this would not be an exception. In this study, the rated $\bar{M}_{ct}$ estimate for an equipment is based on contractor collected field data over a six months span with the field maintenance handicaps (manuals, tools, spare parts, test equipment, unavailability, abnormal problems encountered in repairs, etc.) purged from the data. In the field, these maintenance handicaps either become part of repair time or indirectly contribute to the proficiency drop of the repairman. Table 44 provides a composite listing of the factors that were determined to make up this influence.

As illustrated in figure 12, these factors contributed (on the average) 19.05 minutes to the inherent MTTR (51.25 - 32.2).

Once the ideal base has been established, the next step is to determine the reason for the variance in $\bar{M}_{ct}$ for the seven bases visited. These influences include personnel skill levels, physical environments including lighting facilities, climate and other operational stresses, percent faulty modules repaired at the base, spares availability, stockroom policy, handtools and accessory adequacy, manual up-to-dateness, and test equipment availability. This factor contributed 94 - 51.25 or 42.75 minutes. This 94 minute field average M_{ct} for all equipment was determined by taking the average active reported M_{ct} for all of the equipments studied.

Table 45 summarizes the factors causing the interbase variation with the potential range of influence of each factor given in minutes. As shown some factors can have a negative as well as a positive effect on corrective maintenance time.

The next part of the analysis accounts for the difference between the active and reported M_{ct} estimates at an average base. The basic difference can be attributed to the addition of preparation, cleanup and other administrative times. The major portion of this time is the failure report administration time which takes 10 to 20 minutes to complete. Other factors identified from the base analysis are: test equipment and handtools availability, technical manual availability and format, group failure rate time, and time to obtain spare parts.

TABLE 44

INHERENT MTTR TO IDEAL BASE FACTORS

Factor	Range (minutes)	Typical (minutes)
1) Faulty boards/assemblies are repaired at the ideal base/site.	2 to 10	10
2) Repair concept utilized at the ideal base calls for replacing faulty boards/assemblies.	0 to 4	2
3) Average base repairman proficiency during the first six months equipment operation versus ideal base (Base E) repairman proficiency a year or two later varies moderately.	2 to 10	6
4) Non career oriented operator proficiency improvement in one or two years seldom occurs.	0 to 2	0
5) Percentage of time operator required to do repair is small.	0 to 1	0
6) Standard report forms are used at ideal base (Base E).	0 to 1	0
7) Repairs at the ideal base (Base E) are not grouped in a single report.	0 to 1	0
8) The ideal base (Base E) reported $\overline{M}_{ct}$ is not affected by secondary failures.	0 to 1	1

TABLE 45

FACTORS AFFECTING AVERAGE BASE (SCORE AND RANGE)

Factor Description	Average Base Score	Range
Personnel Skill Rating	+ 3	+ 6 → - 6
Environment (Temperature, Humidity)	+ 2	+ 3 → - 3
Lighting	+ 2	+ 3 → - 3
Operational Stress (Rough Handling, Shock)	+ 2	+ 3 → - 3
Identical Spare Replacement Policy Handicap	- 1	+ 3 → - 3
Percentage Base/Site Board/Assembly Repair	- 2	+ 6 → - 6
Spares Availability	+ 5	+12 → -12
Stockroom Policy (More or Less Liberal)	+ 4	+ 6 → - 6
Handtool Independence	+ 2	+ 6 → - 6
Handtool/Accessory Adequacy	+10	+18 → -18
Manual Availability	+ 1	+ 3 → - 3
Manual Up-to-Dateness	+ 3	+ 9 → - 9
Manual Familiarity	+ 4	+ 9 → - 9
Amount of Training	- 2	+ 6 → - 6
Percentage Military/Career-Oriented Personnel	+ 2	+ 6 → - 6
Test Equipment Availability	+ 7	+12 → -12
Test Equipment Calibration Rating	+ 1	+ 3 → - 3

According to figure 12, the reported subassembly $\bar{M}_{ct}$ for the average base is 111 minutes, and the active M_{ct} for the average base is 94 minutes. This 111 minutes does not include the extreme case M_{ct} for the AN/FYQ-47. With the extreme case, this 111 minutes would be 118.65 minutes. Table 46 summarizes the factors and the degree of influence these factors have.

The next set of factors deal with those operational influences that result from equipment design differences. Table 47 summarizes the factors and their degree of influence on each of the equipment. As can be seen, the AN/GPA-127(V) is most significantly influenced by these factors (+20) while the AN/GPA-124 is the least effected (-26). Again this is directly attributable to the design and support concepts intended for these systems. On the average these factors had a negative 15 minute effect on the M_{ct}.

Up to this point in the analysis, the numbers have been dealing with subassembly repair. This is in concert with the predictions and the assumed maintenance concepts. However, in the Air Force data, there are a large degree of failures attributed to system failures, i.e., could-not-duplicate conditions and interface problems. These failures are not accountable for in the analysis up to this point and must be included if we want to convert MTTR to field M_{ct}. Data from this study has shown that on the average, system failures had very little effect on the M_{ct}; however, system failures in digital equipment increased the field reported M_{ct} while system failures in the analog equipment decreased the reported M_{ct}. Section 6 discusses the factors that caused this variation. Table 39, factor II F shows the degree of influence these system factors have on the overall MTTR.

The previous discussion fully discussed the first step involved in deriving the mathematical model used for the predicted MTTR/field reported M_{ct} conversion. As shown, the initial model was composed of six basic factors. Each factor has been discussed with their relative weights. Table 48 summarizes all of these factors. Note, in table 48, the relative degree of influence can be quantitatively summarized as follows:

TABLE 46

ADMINISTRATION FACTOR (AVERAGE SCORE/RANGE) SUMMARY

Factors	Average Score	Range
Test Equipment Availability	1	$0 \rightarrow 2$
Hand Tools Availability	1	$0 \rightarrow 2$
Non-Career Oriented Repairman	0	$0 \rightarrow 1$
Percentage of Time Operator Required to Repair	1	$0 \rightarrow 2$
Technical Manual Availability	1	$0 \rightarrow 2$
Report Time Affecting Preparation and Cleanup Time	14	$10 \rightarrow 30$
Grouping Failures Effect	1	$0 \rightarrow 2$
Administration and Item Obtainment Time	1	$0 \rightarrow 4$

TABLE 47

FACTOR DEVIATION AMONG EQUIPMENTS

No.	Description	AN/GPA-127(V) Score	AN/FYQ-47 Score	AN/FPS-27A Score	AN/GPA-124 Score	Range
1	Grouped Failure Reporting (Percentage Higher (+) or Lower (-))	+ 1	0	0	- 1	+ 3 to - 3
2	Environment Sensitivity (More (+) or Less (-) Sensitive)	- 2	0	0	0	+ 3 to - 3
3	Physical Proximity Repair Sensitivity (More (+) or Less (-) Sensitive)	+ 1	0	0	- 2	+ 3 to - 3
4	Repair Facility Lighting (Brighter (-) or Dimmer (+))	0	0	0	- 2	+ 3 to - 3
5	Base Repaired Faulty Module (Percentage Higher (+) or Lower (-))	+ 6	+ 4	0	- 8	+27 to -27
6	Base/Site Space Availability (Percentage Higher (-) or Lower (+))	+10	-10	0	- 4	+27 to -27
7	Stockroom Spare Direct Exchange Policy (Percentage Higher (+) or Lower (-))	+ 3	0	0	0	+ 6 to - 6
8	Handtools Tools Availability (Higher (-) or Lower (+))	+ 1	0	0	- 2	+ 3 to - 3
9	Spares Replenishing Plan (Better (-) or Worse (+))	+ 1	0	0	- 6	+ 6 to - 6
10	Technical Manual Availability (Higher (-) or Lower (+))	+ 1	0	0	- 1	+ 3 to - 3
11	Personnel Training (Higher (-) or Lower (+))	+ 4	- 2	0	0	+ 9 to - 9
12	Career Oriented Personnel (Percentage Higher (-) or Lower (+))	0	0	0	0	+ 3 to - 3
13	Test Equipment Availability (Higher (-) or Lower (+))	- 6	- 1	0	0	+15 to -15
	Total Scores	+20	- 9	0	- 26	

0	very small	3 minutes
3	small	5 minutes
5	medium	10 minutes
10	large	15 minutes
15 minutes	very large	

7.2.2 Step Two

Referring to table 48, it can be seen that there are many of the same factors included in the various main influences, for example, (1) failure grouping and (2) the impact of the factor caused by the difference between the predicted assumed and actual practical maintenance concept. Thus by consolidating all the like factors illustrated in table 48 and normalizing the relative degree of influence of each of these factors, a more simplistic model was derived. This new model is the two multiplier model shown in section 7.0.

Table 38 is the composite listing of the consolidated factors along with their relative degree of influence (in multiplier format).

Influences Affecting Field Maintainability	Equipments Affected				Data Source of Factor Determination					Relative Influence On Reported Field Mct
	AN/GPA-127	AN/FYQ-47	AN/FPS-27A	AN/GPA-124	Field Predictions/ Questionnaires	66-1/65-110 AF Data	Contractor Collected Data	MIL-STD 471 Formal M Demo.	Other	
I. Manufacturer Influences										
Prediction Inaccuracies										
• Inaccurate Repair Rate Weighting	X	X	X	X	X	X	X			Very small
• Failure Mode Mismatch (prediction vs. field)	X	X	X	X	X	X	X			Small
• Time Lag (prediction and deployed hardware configuration)	X	X	X	X	X					Very small
• Analyst Pessimism/Optimism		X	X	X	X					Very small
• Prediction Technique Inadequacies	X	X	X	X	X		X	X	X	Small
II. Operational Influences										
Inherent M_{ct} and Ideal Base Differences										
• Repair/Replace Concept Different from Predicted	X	X	X	X	X					Large
• Base Support Policy Differs from M Concept	X	X	X	X	X	X				Very Small
• Proficiency:										
Decay Over Two Year Deployment	X	X	X	X	X					Very Small
Lack of Due to No Practice			X				X	X		Very Small
• Failure Grouping Affecting M_{ct}	X	X	X	X	X	X		X		Very Small
Between Base Differences										
• Personnel Skill Level Variation	X	X	X	X	X					Very Small
• Physical Environment (temperature, humidity)	X	X	X	X	X					Very Small
• Lighting Variation	X	X	X	X	X					Very Small
• Operational Stress Variance (handling, shock)	X	X	X	X	X					Very Small
• Repair/Replace Concept	X	X	X	X	X	X				Very Small
• Non-Base Site Faulty Repair	X	X	X	X	X					Very Small
• Availability of:										
Recommended Test Equipment (operational)	X	X	X	X	X		X	X		Medium
Recommended Handtools and Accessories	X	X	X	X	X					Large
Technical Manuals	X	X	X	X	X					Very Small
Operational Spares	X	X	X	X	X			X		Medium
• Stockroom Policy	X	X	X	X	X					Small
• Personnel Dependence on Tools (need of special)	X	X	X	X	X					Very Small
• Manual Up-To-Dateness and Completeness	X	X	X	X	X			X		Very Small
• Manual Familiarity	X	X	X	X	X					Small
• Training										
Formal Classroom	X	X	X	X	X	X		X		Very Small
Dedicated OJT	X	X	X	X	X	X		X		Very Small
• Non Career Oriented Personnel	X	X	X	X	X					Very Small
• Test Equipment Calibration Rating	X	X	X	X	X					Very Small
• Maintenance Induced Failures	X	X	X	X	X	X	X			Very Small
Active M_{ct} to Reported M_{ct} Differences										
• Report Time	X	X	X	X	X					Very Large
• Group Failure Reporting	X	X	X	X	X	X				Very Small
• Availability										
Recommended Test Equipment (operational)	X	X	X	X	X					Very Small

ployed hardware configuration)										
• Analyst Pessimism/Optimism		X	X	X	X					Very small
• Prediction Technique Inadequacies	X	X	X	X	X		X	X	X	Small
II. Operational Influences										
Inherent M_{ct} and Ideal Base Differences										
• Repair/Replace Concept Different from Predicted	X	X	X	X	X					Large
• Base Support Policy Differs from M Concept	X	X	X	X	X	X				Very Small
• Proficiency:										
Decay Over Two Year Deployment	X	X	X	X	X					Very Small
Lack of Due to No Practice			X				X	X		Very Small
• Failure Grouping Affecting M_{ct}	X	X	X	X	X	X		X		Very Small
Between Base Differences										
• Personnel Skill Level Variation	X	X	X	X	X					Very Small
• Physical Environment (temperature, humidity)	X	X	X	X	X					Very Small
• Lighting Variation	X	X	X	X	X					Very Small
• Operational Stress Variance (handling, shock)	X	X	X	X	X					Very Small
• Repair/Replace Concept	X	X	X	X	X	X				Very Small
• Non-Base Site Faulty Repair	X	X	X	X	X					Very Small
• Availability of:										
Recommended Test Equipment (operational)	X	X	X	X	X		X	X		Medium
Recommended Handtools and Accessories	X	X	X	X	X					Large
Technical Manuals	X	X	X	X	X					Very Small
Operational Spares	X	X	X	X	X			X		Medium
• Stockroom Policy	X	X	X	X	X					Small
• Personnel Dependence on Tools (need of special)	X	X	X	X	X					Very Small
• Manual Up-To-Dateness and Completeness	X	X	X	X	X			X		Very Small
• Manual Familiarity	X	X	X	X	X					Small
• Training										
Formal Classroom	X	X	X	X	X	X		X		Very Small
Dedicated OJT	X	X	X	X	X	X		X		Very Small
• Non Career Oriented Personnel	X	X	X	X	X					Very Small
• Test Equipment Calibration Rating	X	X	X	X	X					Very Small
• Maintenance Induced Failures	X	X	X	X	X	X	X			Very Small
Active M_{ct} to Reported M_{ct} Differences										
• Report Time	X	X	X	X	X					Very Large
• Group Failure Reporting	X	X	X	X	X	X				Very Small
• Availability										
Recommended Test Equipment (operational)	X	X	X	X	X					Very Small
Recommended Handtools and Accessories	X	X	X	X	X					Very Small
Technical Manuals	X	X	X	X	X					Very Small
Operational Spares	X	X	X	X	X					Very Small
Between Equipment Types Differences										
• Multiple Failures (secondary and grouping)	X			X	X	X				Very Small
• Equipment Environmental Sensitivity	X		X		X					Very Small
• Physical Proximity (system parts and AGE monitoring)	X			X	X					Very Small
• Lighting				X	X					Very Small
• Repair/Replace Concept	X	X		X	X					Medium
• Stockroom Policy	X	X	X	X	X					Very Small
• Spares Pipeline Policy	X			X	X					Very Small
• Training Requirements	X	X		X	X					Small
• Availability										
Recommended Test Equipment (operational)	X	X		X	X					Small
Recommended Handtools and Accessories	X			X	X					Very Small
Technical Manuals	X	X	X	X	X					Medium
Operational Spares	X			X	X					Very Small
• Percentage Career Oriented Personnel				X	X					Very Small

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8. CONCLUSIONS AND RECOMMENDATIONS

This section presents the conclusions and recommendations that have been derived from this study. Four basic observations have been made as a result of this study:

- **Field equipment availability is relatively unaffected by reported M_{ct}'s which on the four equipments studied vary from 2.5 to 5.8 times the predicted MTTR.**
- Maintenance technician proficiency is directly related to the amount of repair practice.
- Field reported M_{ct} is dependent on the system design concept.
- The operational influences compose at least 66% of the factors that effect the difference between predicted and field reported M_{ct}. Specific details on each of these topics are included in paragraphs 8.1 through 8.4. Recommendations resulting for the data and conclusions derived in this study are included in section 8.5.

8.1 FIELD AVAILABILITY

Availability can be considered as a combination of two factors:

- An "intrinsic" availability achieved in design - the probability that the equipment will be operationally ready when needed under specified conditions of maintenance and logistic support.
- An availability degradation factor experienced in use - the degrading effect of actual use conditions on maintainability and supportability of the equipment, attributable to the degree of qualification of maintenance personnel, adequacy of test and repair facilities, and sufficiency of spares provisioning.

Table 49 displays these two availabilities of the four equipments studied. As shown with the high achieved field MTBF's, intrinsic availability is only slightly affected by the operational influences on $\underline{M}$. The largest variation in availability attributed to in-use degradation occurred on the AN/FPS-27A. The primary reason for this was the relatively smaller achieved field MTBF rather than a significant variation (from other equipments studied) in M_{ct}.

TABLE 49

EQUIPMENT AVAILABILITY PARAMETERS

Equipment	MTBF (Hrs.)		Predicted MTTR Minutes	Field Reported M_{ct} Minutes	Availability	
	Predicted	Field			Intrinsic	"In-Use" Degraded
AN/GPA-127(V)	1021	667	39.5	148.2	.999	.996
AN/FYQ-47	663	324	24.3	121.8	.999	.994
AN/FPS-27A	370	490	23	111.6	.999	.996
AN/GPA-124	1203	1894	48.8	93	.999	.999

For some systems the duration of single down times may be the most meaningful measure of system effectiveness. For ground based early warning radar systems both availability and the duration of single downtimes are measures of effectiveness. The reason for choosing the latter as an important measure is that if an enemy knew the system was to be down, on the average, for an extended period of time, sneak attacks could be employed. Thus, systems with high availabilities (>0.995) and moderately short field M_{ct} (<2 hrs) are considered effective.

Durations of single downtimes can also be related to a penalty cost which must be paid for each consecutive unit time the system is unavailable. An air traffic control system that establishes flight plans and directs the landing and take-off of aircraft is an example. Long durations of single downtimes may mean queing at take-off, thereby delaying schedules, lost flights, and so on. Thus a trade between MTBF and M_{ct} must be made to achieve the required availability for a particular system application.

If a failure of a particular system results in large financial penalties attributed to the performance (and not maintenance costs) of the system, M_{ct}'s should be minimal. However, if the cost per maintenance action exceeds the cost to achieve high reliability in the design, maintenance frequency may be minimized with a lesser degree of emphasis on M design. This generally is the case in military applications as long as the field M_{ct} is kept below some level. In the case of the four equipments evaluated in this study, field reported M_{ct} varied from 1.55 to 2.47 hours, and this degraded "in-use" M_{ct} could be improved significantly through the proper employment of the M and supportability concepts for which the equipments were designed. However, operational availability was relatively high and the applications for which each of the systems were being used does not require extremely low M_{ct}'s. Also, system cost in these cases are minimized through maintenance to the lowest level possible, thus eliminating cost of sparing larger subassemblies and assemblies.

8.2 OPERATIONAL PROFICIENCY

Operational proficiency proved to be an influence which basically contradicts the design philosophy of the equipment studied. In general, military systems are designed to achieve the highest reliability possible. As illustrated in table 50, MTBF's greater than 324 hours were being achieved in the field environment on all equipments studied. Based on 24 hours/day operation, this amounts to less than 2.22 maintenance actions per month, and with three operating shifts/day, at most a technician will perform no more than 1 corrective maintenance action per month. This high reliability proves to be detrimental to the maintenance of the technician's proficiency, and, in fact aids in the decay of proficiency over extended periods of time.

Maintainability Demonstration Test program data can best illustrate how maintenance practice can effect proficiency. In general, $\underline{M}$ demonstration tests require simulated fault samples sizes from 50-100. This means typically that during a particular demonstration test, one type of maintenance on a particular subassembly/board will be experienced numerous times. In this, demonstrated repair times should decrease with the increased degree of familiarity and practice. This, in fact, was the case for the AN/FPS-27A Maintainability Demonstration. As illustrated in figure 15, maintenance of the VGA board in the AN/FPS-27A was demonstrated eleven times, and on the average, M_{ct} improved from 26.5 minutes to 12 minutes over a period of 9 calendar days (4 January to 13 January 1973). Thus, if this degree of proficiency is important in the usage application and must be maintained, equipment reliability must be reduced an obviously unrealistic approach or fault simulation with repair should be scheduled in a fashion similar to preventative maintenance intervals. Again, the need for this stems from the availability requirement and the trade-off made between MTBF, MTTR, cost, and performance to achieve this availability.

TABLE 50

UNSCHEDULED MAINTENANCE ACTION FREQUENCY

Equipment	Total Actions	Time Span	Squadrons Used	Actions Per Squadron Per Month
AN/GPA-127	196	9 Months	20	1.08
AN/FYQ-47	200	9 Months	10	2.22
AN/FPS-27A	120	12 Months	7	1.43
AN/GPA-124	144	12 Months	32	0.38

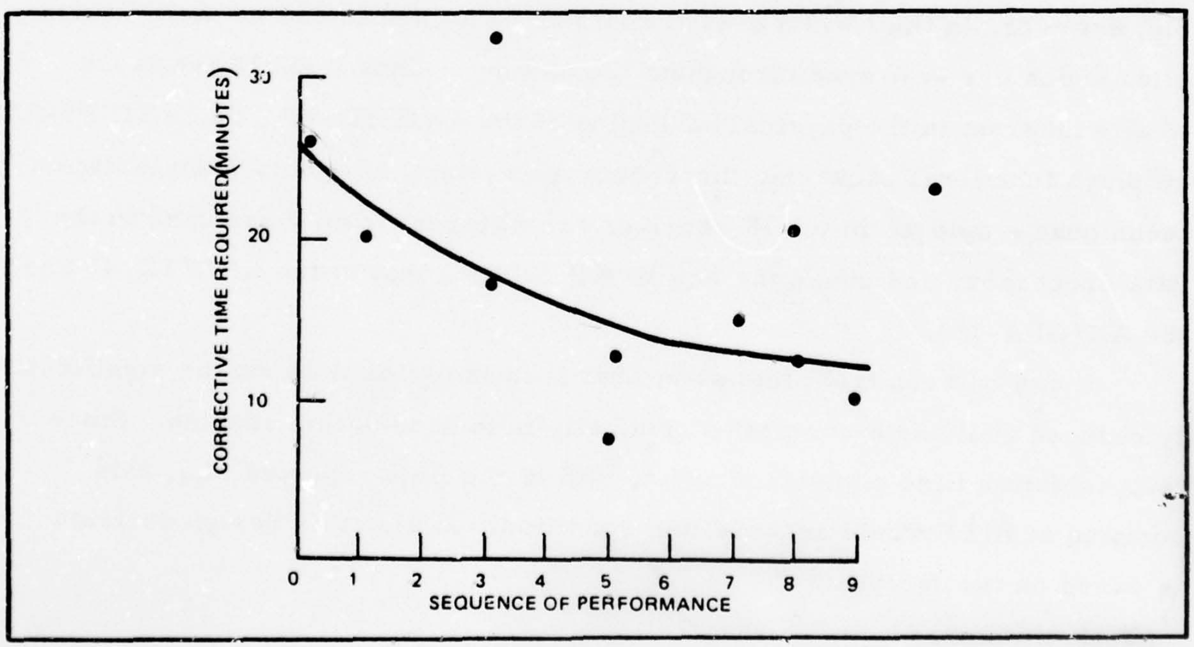


Figure 15. AN/FPS-27A VGA Demonstration Data

8.3 EQUIPMENT DESIGN CHARACTERISTIC COMPARISON

As illustrated in table 51, the four equipments studied have four distinctly different design, application, and support philosophies. As shown, the AN/GPA-127(V) has the highest reported field M_{ct}. This can be directly attributed in part to two design characteristics:

- Lack of BIT capability resulting in manual diagnostic procedures.
- "On-line" component remove/replace maintenance concept.

The AN/GPA-124 has the smallest M_{ct}. The maintenance concept for this system, along with the AN/FPS-27A and AN/FYQ-47, is PCB remove/replace. Thus, with an effective use of BITE and external test equipment, fault isolation can be reduced significantly. An additional factor which makes the AN/GPA-124 M_{ct} lower than the AN/FYQ-47 is the employment of functional packaging. The AN/FYQ-47 is not packaged functionally as is the AN/GPA-124. Thus where a fault is detected and isolated to an equipment function, it will totally be contained in a particular AN/GPA-124 subassembly; however, in the AN/FYQ-47 it could be contained in one or more assemblies which are scattered throughout the cabinet. Thus localization is not totally inherent in the physical packaging of the AN/FYQ-47. The AN/FPS-27A employs functional packaging throughout the system; however, fault isolation techniques employed in the IF receiver are different from those used in the data processor, and cause the M_{ct} to fall between that of the AN/FYQ-47 and the AN/GPA-124.

It can be seen from this data, that fault isolation time can be significantly reduced utilizing a comprehensive built-in fault isolation scheme. Since fault isolation time comprises 50% to 80% of the field reported M_{ct}, this addition of BITE would enhance this condition. Again, this design decision is based on two factors:

- Is minimal M_{ct} necessary ?
- Can the acquisition cost of these equipments afford the additional cost for BITE?

TABLE 51

EQUIPMENT DESIGN CHARACTERISTIC COMPARISON

Equipment	Design Characteristics	Field Reported M_{ct} HR	Fault Isolation/ Checkout Procedure
AN/GPA-127(V)	• Analog/Vacuum Tube Display System • Component Remove/ Replace	2.47	No Bite, Uses External Test Equipment
AN/FYQ-47	• Digital/Solid State Data Processor • Printed Wiring Assembly Remove/Replace	2.03	Fault Detection via Bite, Fault Isolation Combines Bite and External Test Equipment
AN/FPS-27A	• Digital/Solid State Data Processor and IF Receiver • Printed Wiring Assembly Remove/Replace	1.86	Same as AN/FYQ-47
AN/GPA-124	• Analog/Digital Solid State Data Processor • PWA Remove/Replace	1.55	Same as AN/FYQ-47

8.4 MANUFACTURER/OPERATIONAL INFLUENCE RELATIONSHIP

As illustrated in Section 7, the influences identified in this study were divided into two subgroups; manufacturer's and operational. The potential mathematical ranges for these relationships are as follows:

$0.67 \leq [Z_1] \leq 1.87$

$0.66 \leq [Z_2] \leq 10.00$

However, on the average $Z_1 = 1.20$ and $Z_2 = 3.78$ for a composite $[Z_1 Z_2]$ of 4.5. Quantitatively, this means that the operational factors influencing the field reported M_{ct} comprise as much as 84% (3.78/4.5) of the influences causing the difference between predicted MTTR and field reported M_{ct}. This range is dependent on such factors as:

- BITE effectiveness.
- Remove/replace philosophy.
- Training required.
- Available recommended test equipment.
- Stockroom policy.

If the influence of these operational factors were to be reduced, design and maintenance support concepts must be "designed into" the prime equipment in the early design phase of an equipment, and these concepts must be in concert with the equipment procuring agencies deployment and support policies. As seen throughout this study, deviations from any of the design/support concepts generally result in longer repair times.

8.5 RECOMMENDATIONS

The mathematical model derived in this study is a heuristic model reflecting data from four system designs and primarily seven operational bases. This model fits the base and equipment data studied. The approach employed in deriving this model is universal in nature; however, the values for the various factors (Z's) are limited because:

- The Air Force sites visited were homogeneous in purpose.
- Field data collection was limited to four system types even though the design/intent of the systems studied are variant in technology, design content, and system application.

- The field data collected was time period limited.

The primary recommendation made as a result of this study is to visit additional Air Force ground site types; e.g. strategic, tactical, and mobile. In this, potential new influences and various degrees of effect of the existing influences can be determined and included in the model.

Westinghouse does not believe that studying additional equipment types would be extremely beneficial to the study results. As illustrated in Section 6, inter-equipment type influences and their qualitative effect on predicted MTTR can be predicted via the present mathematical models depicted in MIL-HDBK-472. The $[Z_1]$ factor showed a potential range from 0.67 to 1.87 but on the average is 1.20 which means that the inherent accuracy of MIL-HDBK-472 predictive methods are within 20% of the inherent field MTTR.

The final recommendation is to sample data on the systems studied at the bases visited several years after the first sampling. This would provide some additional statistical validity in the data used since the maintenance personnel would be different from those interviewed as part of this study.

APPENDIX A

FIELD MAINTENANCE DATA ANALYSIS

This appendix describes the methods used in analyzing the Air Force Field Maintenance Data (66-1/65-110)

APPENDIX A
FIELD MAINTENANCE DATA

A.1 DEVELOPMENT OF THE FIELD MAINTENANCE TIME VALUES

The AF Maintenance Data Collection (MDC) System (under AFM 66-1) provides extensive maintenance information performed on electronic equipment in the Air Force. When maintenance is performed (either on-equipment or off-equipment), a maintenance record is accomplished (AFTO Form 349) containing specific information on the reason maintenance was required, when it was performed, what equipment and what major assembly of the equipment required the maintenance, what was found, what was done to correct the fault found, and the length of time required to perform the corrective actions. These records are officially recorded and, in most cases, cardpunched and put on tapes for long-term use and storage. The maintenance form is normally retained at the originating organization for a relatively short time after card-punch has been accomplished, a period of time which may vary from 30 to 180 days prior to disposing.

For this study of field-experience, operational usability, these MDC records were selected for analysis as the most comprehensive and readily available source of maintenance information. Tapes available from Hqts AFLC, Wright-Patterson AFB, Ohio were initially utilized. These tapes were selected on the basis of content for specific ground electronic systems and covered a specific period of time. An arbitary time base of 1 year was chosen, 1 July 1973 to 30 June 1974, to achieve a sufficiently broad statistical base and to analyze over the most recent segment of maintenance data collated just prior to this study.

An initial check made of the first tape received and its formatted printout revealed that the most important parameter of a maintenance action (MA)

needed for this study, was no longer part of the record. Elapsed maintenance time (EMT) for each specific maintenance action had been converted into maintenance man-hours (MNH) through computing the difference between the start of maintenance and the stop time and multiplying by the size of the crew used. Another source of information was therefore required to augment these maintenance records in order to derive meaningful EMT. Hqts, Aerospace Defense Command, whose systems were the subject of this study, was solicited for records available on maintenance performed during the period of interest. Printouts, also made under the MDC system of data collection, were received. These were compared with the AFLC tape record and found to be in most cases identical, except for an insignificant difference in quantity of records. Minor differences of format were found in organizational designation codes used and method of indicating the data maintenance was performed; consequently, records from either headquarters could be used.

It was also found that an equipment status (ESR), AF Form 182, is prepared at the organizational location to record operational status of electronic equipment and changes thereto which effect their operational readiness. These records are cardpunched and transmitted to Hqts ADC where maintenance analysis can utilize them for various command programs (reference ADCM-65-1). Consequently, printouts of these records were requested and found to be of major importance in correlating specific maintenance actions with equipment downtimes.

A.2 DATA FORMATS

A.2.1 MDC Data

Maintenance records used in this study were compiled on tape within the Air Force Maintenance Data Collection system and made available upon request. The selection criteria for the appropriate records were: equipment nomenclature, dates of record initiation, and unscheduled maintenance. Data received from Hqts, AFLC was on magnetic tape and was processed through a Westinghouse in-house computer against a written program for sort into

a format. Maintenance data on the tape was organized into a standard 80-column format, which is shown in figure A-1 for both on-equipment and off-equipment records. Interest was concentrated on the on-equipment records to determine the organizational level maintenance characteristics actually encountered in the operational units.

Information cardpunched into the 80-column format is taken from the AFTO Form 349, prepared by the maintenance activity performing the maintenance. On-equipment maintenance on CEM equipment is placed on a Card Code "0" identified in column 80. Each maintenance action record extracted from cumulative tapes processed at AFLC contained the information as shown in figure A-1.

Equipment Identification	-	MDS (Mission/Design/Series) Serial Number Prefix and Suffix of Work Order of the Equipment Classification
Organization	-	Command Location or Installation Code Owning Work Center
Job Control Identification	-	Job Control Number Tag No. (Off-Equipment Only)
Work Identification	-	Card Code (for On-Equipment Ident.) Work Order Data (Accomplished)
Failure Identification	-	Work Unit Code (Lowest Assy Work Identified to) How Malfunctioned Time (If Caused Downtime) When Discovered
Maintenance Action Identification	-	Action Taken Units of Action (Compared or Not Completed) Labor (Man-Hours)

To convey as much information as possible and to simplify the task of preparing a record for each maintenance job performed, abbreviations for data elements and their definitions for use are contained in AFM 300-4, Vol. XI. Extracts from the manual, with definitions for certain specific CEM (communications-electronics-meteorological) equipment maintenance codes

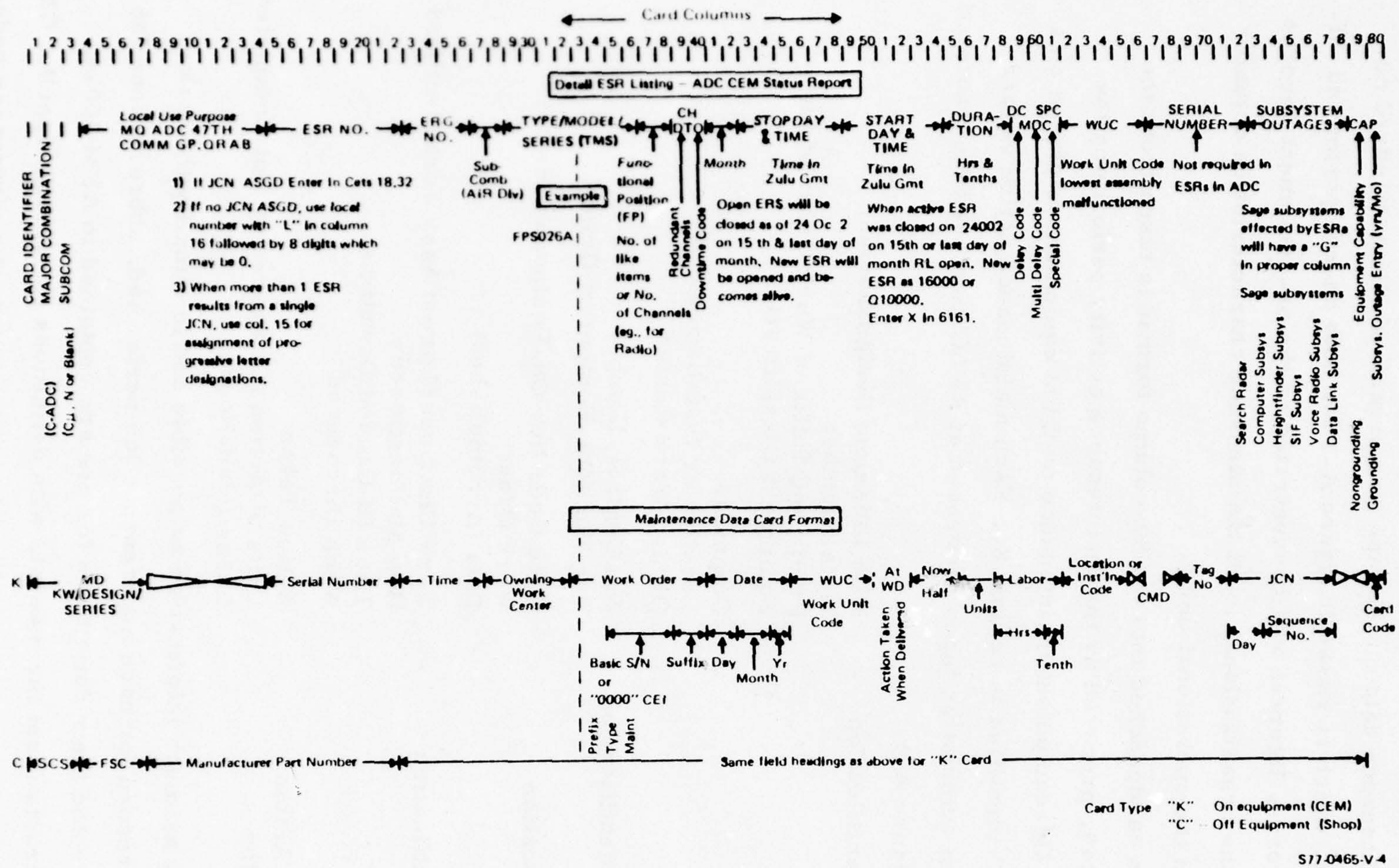


Figure A-1. Card Formats - Equipment Status Report (ADC) and AFM 66-1 Maintenance Record (AFLC/ADC)

used in these records are contained in paragraph A.4.1. Coding is illustrated for the categories of maintenance action taken, type maintenance, and when discovered. By application of these data elements to the sort and printout of the information from the Maintenance Form AFTO 349, a reconstruction of each failure and its correction can be made.

Hqts, ADC made records already in printout format for this study available. Records were presorted by organization, type equipment, and date of performed maintenance and were further arranged by job control number (JCN) for easier comparison with other associated records. The JCN is a 7-digit element whose first 3 digits are the Julian date of issue and whose last 4 elements are sequentially assigned for job control purposes. This date may be the same as the date when maintenance was performed, particularly for on-equipment work, but may not be in the case of deferred maintenance. When records are grouped by JCN, the chronological sequence of maintenance actions is seen. Furthermore, all associated records attributable to a single equipment deficiency are grouped although the span of time may cover days, weeks, or even months. Further sorting was done to eliminate all records except on-equipment work and unscheduled maintenance, which reflects an unanticipated failure. Records which reflected JCN's issued prior to the period of interest, even though the actual maintenance may have been performed during the year, were also eliminated. A sample page printout is shown in figure A-2.

This report also uses abbreviations and definitions compiled in AFM-300-4, Vol. XI, where the data elements concern maintenance aspects of the equipment's status. Downtime and delay codes are extracted from AFM-300-4 and are shown in paragraph I.4.2. These codes and others peculiar to the preparation of the ESR are also given in ADCM-65-1, CEM Equipment Status Report, RCS:HAF-LGY(D) 7151.

From the ESR records available, printouts were provided by equipment type, organization, time period (1 July '73-30 June '74) and downtime codes F, M, and R (failed flight check, malfunction, and emergency-depot

ON AND OFF EQUIPMENT DATA LISTING (0 AND 3 CARDS)

TMS/ MDS/FSC	PART OR SERIAL NUMBER	TIME	WORK CNTR	TYPE MAIN	ECC	BASIC WO/NO	D/M/Y	WUC	A/T	W/D	HOW MAL	UNITS COMP	HOURS/ TENTHS	ORG	JCN	FAIL CODE	ID
GPA127	00000845		T640B	D	ETZ	0845	01103	AGBC0	Y	J	255	01	0006	0765	2442001	2	0
GPA127	00000845		T640B	D	ETZ	0845	19103	AGBC0	G	J	255	01	0020	0765	2442001	2	0
GPA127	00000836		T640B	B	ETZ	0836	26103	AGB00	Y	D	255	00	0080	0765	2491005	2	0
GPA127	00000836		T640B	B	ETZ	0836	27103	AGB00	Y	D	255	00	0056	0765	2691005	2	0
GPA127	00000836		T640B	B	ETZ	0836	27103	AGB00	Y	D	255	01	0016	0765	2691005	2	0
GPA127	00000836		T640B	B	ETZ	0836	27103	AGBC0	G	D	255	01	0014	0765	2691005	2	0
GPA127	00000836		T640B	B	ETZ	0836	27103	AGBD0	G	D	255	01	0006	0765	2691005	2	0
GPA127	00000845		T640B	S	ETZ	0845	27103	AGBA0	G	R	106	01	0003	0765	2701004	2	0
GPA127	00000845		T640B	S	ETZ	0845	27103	AGBD0	G	R	472	01	0003	0765	2701004	2	0
GPA127	00000123		T540B	S	ETZ	0123	27103	AGBD0	G	R	472	01	0004	0765	2701005	2	0
GPA127	00001024		T640B	S	ETZ	1026	27103	AGBD0	G	R	106	01	0004	0765	2701006	2	0
GPA127	00000836		T640B	S	ETZ	0836	27103	AGBC0	V	R	230	01	0010	0765	2701007	2	0
GPA127	00000836		T640B	S	ETZ	0836	27103	AGBD0	G	R	106	01	0002	0765	2701007	2	0
GPA127	00000836		T640B	B	ETZ	0836	11103	AGBC0	G	D	135	01	0030	0765	2711001	2	0
GPA127	00000123		T540B	B	ETZ	0123	18103	AGBB0	G	D	255	01	0040	0765	2911002	2	0
GPA127	00000123		T640B	B	ETZ	0123	18103	AGBC0	L	D	583	01	0006	0765	2911002	2	0
GPA127	00000836		T640B	D	ETZ	0836	18103	AGBC0	G	J	583	01	0020	0765	2912002	2	0
GPA127	00000836		T640B	D	ETZ	0836	18103	AGBC0	Y	J	583	01	0092	0765	2912002	2	0
GPA127	00000123		T640B	D	ETZ	0123	31103	AGBC0	G	J	080	01	0001	0765	3042005	2	0
GPA127	00000123		T640B	D	ETZ	0123	31103	AGBC0	G	J	135	01	0002	0765	3042005	2	0
GPA127	00000123		T640B	D	ETZ	0123	31103	AGBC0	Y	J	583	00	0002	0765	3042005	2	0
GPA127	00000836		T640B	B	ETZ	0836	14113	AGBC0	G	D	255	00	0060	0765	2981005	2	0
GPA127	00000836		T640B	B	ETZ	0836	14113	AGBC0	Y	D	255	01	0076	0765	2981005	2	0

DATE 10/10/74 PRODUCT PAGE 142 INQUIRY NUMBER 45 PAGE 47

Figure A-2. Sample JCN Printout

level maintenance). These downtime codes define unscheduled maintenance as opposed to scheduled maintenance, TCTO, and other downtime. For use directly in comparison with the maintenance records, the ESR reports (for a particular equipment and organization) were arranged chronologically by ESR No. (or JCN) and month/day of the year interest. A sample page of ESR data is formatted and received from ADC is shown in figure A-3.

A.2.2 Equipment Status Report (ESR)

An ESR (AF Form 182) may be used by ADC Division's Job Control to report status information on mission essential CEM equipment. An alternate form, AF Form 2445 (Job Control Document), may also be used for recording status changes. However, either may be used to report changes in status of CEM equipment, or to report delays encountered in returning an item to a fully operational status (ADCM 65-1, para. 2-9).

For use in performing this study analysis, ADC made available printouts of selected ESR report records to correlate with the maintenance records described in the previous paragraph. A formatted data presentation of the ESR is shown in figure A-1.

Equipment Identification	-	Type/Model/Series Functional Position (No. of like items)
Organization	-	Major Command (ADC) Subcommand (Special Entry) Subcommand (Air Div. or other) Organization No. (Sqdn)
Job Control Identification	-	ESR No. (either associated JCN or local asgd no.)
Failure Identification	-	DTC (Downtime Code) WUC (Work Unit Code) Channel (No. for redundant channels or reportable component) Subsystem Outages (Effected SAGE Subsystem) Capability (Equipment Capability-Grounding or Nongrounding incident)

PREPARED BY OFFICE OF OPERATIONS ANALYSIS.
OFFICE OF PRIMARY RESPONSIBILITY.....FSR STUDY LGMXM
JULY THRU DEC 1971 FAILURES FPS027

ESR	UNIT	AD	TMS	FP	CH	DTC	MO	STOP	START	DUR	DC	MD	SPC	WUC	SU	CAP	MAINT	DOWN	DELAY
581002	6550	21	FPS027A	00	1	M	07	11 1400	01 0000	2540			X	AKKB0		AG		254.0	
581002	6550	21	FPS027A	00	1	M	07	11 1345	01 0000	2538	V	C	X	AKKB0		AG			253.8
921001	6550	21	FPS027A	00	1	M	07	15 2400	11 1405	1059				AKF00		AG		105.9	
921001	6550	21	FPS027A	00	1	M	07	11 1500	11 1410	0008	J	A		AKF00		AG			.8
921001	6550	21	FPS027A	00	1	M	07	15 2400	11 1500	1050	N	B		AKF00		AG			105.0
1971010	6550	21	FPS027A	00	1	M	07	31 1550	16 0001	3758				AKF00		AG		375.8	
1971010	6550	21	FPS027A	00	1	M	07	16 1800	16 0001	0180	N	A		AKF00		AG			18.0
1971010	6550	21	FPS027A	00	1	M	07	23 1150	16 1800	1618	N	B		AKF00		AG			161.8
1981002	6550	21	FPS027A	00	2	M	07	17 1420	17 1415	0001				AKD00	0	RG		.1	
2021001	6550	21	FPS027A	00	2	M	07	22 0055	21 2225	0025				AKV80	0	RG		2.5	
1971010	6550	21	FPS027A	00	1	M	07	23 1420	23 1410	0002	J	C		AKF00		AG			.2
1971010	6550	21	FPS027A	00	1	M	07	26 1200	23 1420	0697	N	D		AKF00		AG			69.7
1971010	6550	21	FPS027A	00	1	M	07	26 2100	26 1300	0080	V	E		AKF00		AG			8.0
1971010	6550	21	FPS027A	00	1	M	07	27 0005	26 2300	0011	J	F		AKF00		AG			1.1
1971010	6550	21	FPS027A	00	1	M	07	31 1450	27 0005	1107	N	G		AKF00		AG			110.7
2121002	6550	21	FPS027A	00	1	M	07	31 2150	31 2040	0012				AKF00		AG		1.2	
TOTAL MONTH																			
																	10.4	739.5	729.1
2131001	6550	21	FPS027A	00	0	U	08	01 0425	01 0310	0013					0	RG		1.3	
2131002	6550	21	FPS027A	00	1	M	08	01 1920	01 1315	0011				AKX00		AG		1.1	
200T092	6550	21	FPS027A	00	1	M	08	03 1315	03 1215	0010				ALFA0		AG		1.0	
1071002	6550	21	FPS027A	00	1	M	08	07 0015	06 1500	0093				ALB00		AG		9.3	
2201001	6550	21	FPS027A	00	0	M	08	08 1455	08 1235	0023				APAS0	0	RG		2.3	
228X092	6550	21	FPS027A	00	1	M	08	15 2400	15 1345	0103				ALH00		AG		10.3	
226X092	6550	21	FPS027A	00	1	M	08	15 1425	15 1410	0003	J	A		ALH00		AG			.3
228X092	6550	21	FPS027A	00	1	M	08	15 2400	15 1425	0096	N	B		ALH00		AG			9.6
228X092	6550	21	FPS027A	00	1	M	08	20 2110	16 0000	1172			X	ALH00		A0		117.2	
228X092	6550	21	FPS027A	00	1	M	08	20 1800	16 0000	1140	N	B	X	ALH00		AG			114.0
2291001	6550	21	FPS027A	00	2	M	08	17 0950	17 0845	0011				BK0AF	0	RG		1.1	
2301001	6550	21	FPS027A	00	0	M	08	18 1845	18 1755	0008				AKW00	0	RG		.8	
2391010	6550	21	FPS027A	00	2	M	08	18 2120	18 2050	0005				AKV00	0	RG		.5	
2311001	6550	21	FPS027A	00	0	M	08	19 2300	19 2205	0009				BKDBA		AN		.9	
2351002	6550	21	FPS027A	00	2	M	08	25 0500	24 1420	0147				AKJ00		AG		14.7	
2351002	6550	21	FPS027A	00	2	M	08	25 0500	24 1700	0120	V	A		AKJ00		AG			12.0
2401001	6550	21	FPS027A	00	1	M	08	31 2400	28 1755	0781				AKFF0		AG		78.1	
2401001	6550	21	FPS027A	00	1	M	08	28 2355	28 1955	0040	J	A		AKFF0		AG			4.0
2401001	6550	21	FPS027A	00	1	M	08	31 2400	28 2355	0721	M	B		AKFF0		AG			72.1
2431003	6550	21	FPS027A	00	0	M	08	31 1730	31 1600	0015				AAEB0		AN		1.5	
TOTAL MONTH																			
																	28.1	240.1	212.0
2401001	6550	21	FPS027A	00	1	M	09	05 2359	01 0000	1280			X	AKFF0		AG		120.0	
2401001	6550	21	FPS027A	00	1	M	09	05 1215	01 0000	1083	M	B	X	AKFF0		AG			108.3
247A092	6550	21	FPS027A	00	0	M	09	04 1215	04 1200	0003				APAVB	0	RG		.3	

040801242L

Figure A-3. Sample ESR Printout

Downtime Identification	-	Month Stop Day and Time Start Day and Time Duration (of downtime status) DC (Delay Code) MDC (Multiple Delay Code)

A.2.3 Correlation of Data

For purposes of this study, a comprehensive data base was sought to provide a wide sampling of maintenance actions performed on typical CEM equipment by representative maintenance organizations. It was the intent to determine actual achieved MTTR on components or major subassemblies of electronic systems and compare these times with initial predictions of MTTR. This type maintenance would be restricted to on-equipment work in a ground maintenance environment. In an initial study of maintenance records in the MDC system, it was found that elapsed maintenance time (EMT) for each maintenance action (troubleshoot), remove and replace, repair, adjustment/alignment) of a maintenance task (Job Control Number-JCN) was not in the data. Conversion to maintenance man-hours had been made which was reported on the record as a labor in hours and tenths of hours. This translation was made by use of the simple formula:

$$MMH = \frac{\text{Stop Time - Start Time (in 5 minute increments) x Crew Size}}{60} \qquad \text{(A-1)}$$

In order to recover EMT for each task, either the crew size must be determined or the stop and start time must be found. Only for those maintenance records containing an entry in the Time block could the extent of system downtime be determined. These records were those with the "When Discovered" code of "C" (during equipment operation/caused equipment downtime) and were less than 25 percent of all the unscheduled maintenance records. For those JCN's which had several maintenance actions before the malfunction was cleared, total system downtime did not provide the necessary information for each action taken. The ESR report was then obtained from ADC.

The ESR report typically contains information relative to a piece of CEM equipment when it no longer is considered to be operationally ready (OR). When it malfunctions, or in the case of 416L equipment, when it can no longer pass, process, or present acceptable data, an ESR is open on the reportable equipment. All time periods in excess of 3 minutes downtime are to be reported. Consequently, the ESR report presents time the equipment becomes not operationally ready (NOR), timedown due to a maintenance requirement (NORM), timedown due to supply responsibilities (NORS), or timedown due to other causes (NORO). When the incident is related to a maintenance task which requires a maintenance record to be opened with its controlling JCN, the ESR number will carry the JCN number. It will also identify the Work Unit Code (WUC) applicable to the lowest level assembly to which maintenance was identified. The JCN, the date the equipment became NOR, and the WUC are all correlateable elements to the maintenance record.

An example of a typical exercise to determine crew size and consequently EMT is as follows:

$$\text{Labor (MMH)} = \frac{\text{EMT (5-min increments)}}{\text{60 min/hr}} \times \text{Crew Size} \qquad \text{(A-2)}$$

$$\text{Labor (Hr)} = \underline{\text{EMT (5-min increments)}} \times \underline{\text{Crew Size}} \qquad \text{(A-3)}$$

Given: 1.7 Hr
or
102 min
(Round Off)

100 or 105 min	100 or 105	1
	50 or 52 1/2	2
	33 1/3 or 35	3
	25 or 26 1/4	4
	20 or 21	5
	16 2/3 or 17 1/2	6
	14.3 or 15	7

(Delete EMT for other than that divisible by 5)

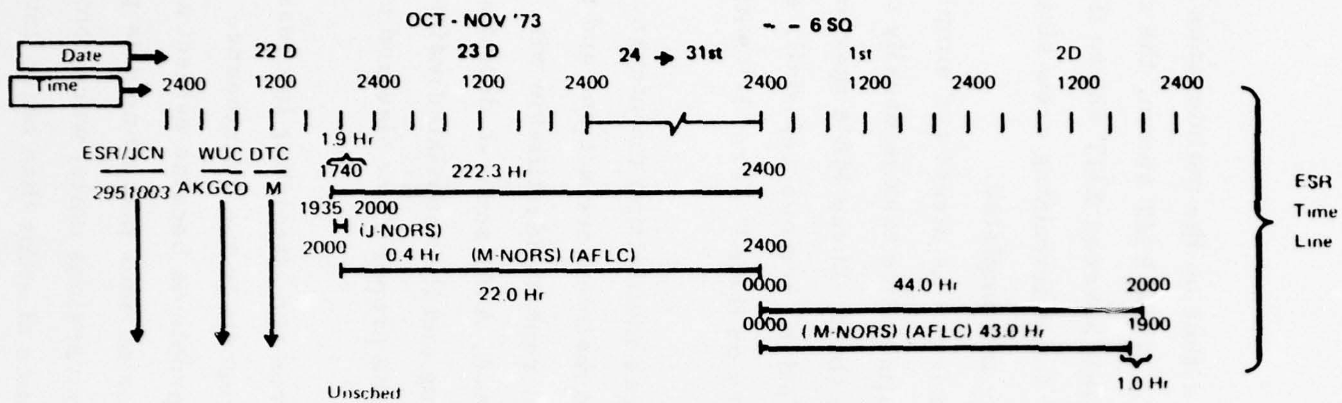
EMT	Crew Size
100 or 105	1
50	2
35	3
25	4
20	5
15	7

Check for record of system downtime (DT) either on the maintenance record or the associated ESR. If DT appears as one of the EMT shown, the crew size will be as indicated. If DT is found to fall between EMT shown (for example: 45 min), assume next lower EMT for determining crew size since the system will not be OR until maintenance is completed.

Determining crew size and elapsed time is not as direct and simple as the aforementioned example imples since a maintenance task is usually composed of more than one maintenance action (MA). These MA's may be troubleshoot, remove and replace, adjust/align, remove/reinstall, etc. Each separate MA requires a new line entry on the AF Form 349 with its associated start/stop time and crew size.

The degree of difficulty in resolving these multiaction maintenance tasks is in direct ratio to the number of discrete maintenance actions and the sequence of downtimes reported in the ESR reports identifiable with the proper JCN and work unit code. Figures A-4, A-5, and A-6 depict a correlation between a typical ESR reporting and the associated maintenance record(s) with the rationale for selecting the proper crew size and consequently EMT.

In analyzing the records of each squadron and attempting to cross-ref reference time sequences from the ESR reports to the maintenance performed (as recorded by JCN's), several problems became evident and had to be resolved. For an example, it became obvious that some data processing locations (card-punch and tape conversions units) were computing labor (or man-hours) in a different sequence of steps than other units. Some converted elapsed time to hours and tenths and then multipled by crew size:



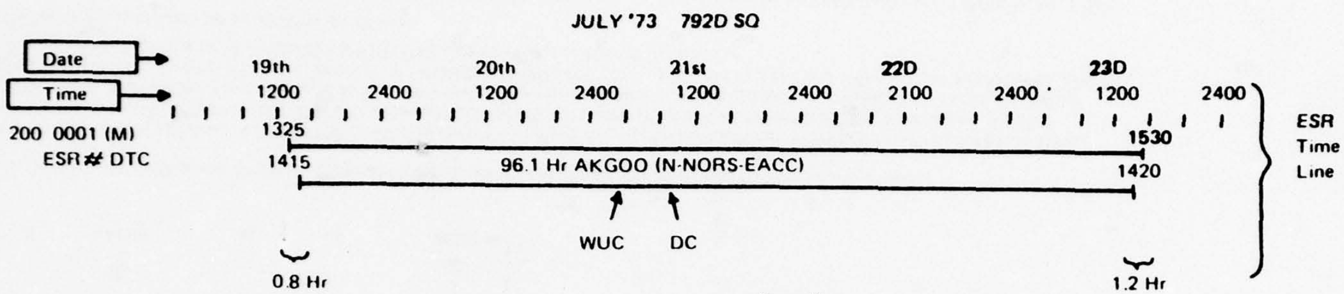
JCN	Unsched Maint. TM	WUC	AT	Hr/Tenths	Sys D.T.	D/M/Yr	Crew Size 2	3	4
2951003	8	AKG00	Y	3.6	–	22103	1.8	1.2	0.9
↓	8	AKG80	G	4.0	-	02113	2.0	–	1.0

Maintenance started at 1740 upon system downing. At 1935 hr the delay code for the downing was shown as "J" (NORS – Supply Processing). Elapsed time from 1740 to 1935 hr is 1 hr 55 min. If a 2-man crew TROUBLESHOT (Y) the failure, labor hr would be ≈ 1 hr 50 min or 1.8 hr per man, or 3.6 hr for the 2-man task.

The system continued in a delay code status due to "M" NORS until 1900 hr, 2 Dec. The system then reverted to down status for 1 more hour due to "M" MALFUNCTION (downtime code) until it was brought up at 2,000 hr. This last hour was **spent REPAIRING (G) with a 4 man** crew for a total of 4 hr labor (MM Hr.).

S77-0465-V-3

Figure A-4. ESR and Maintenance Record Correlation, Example 1



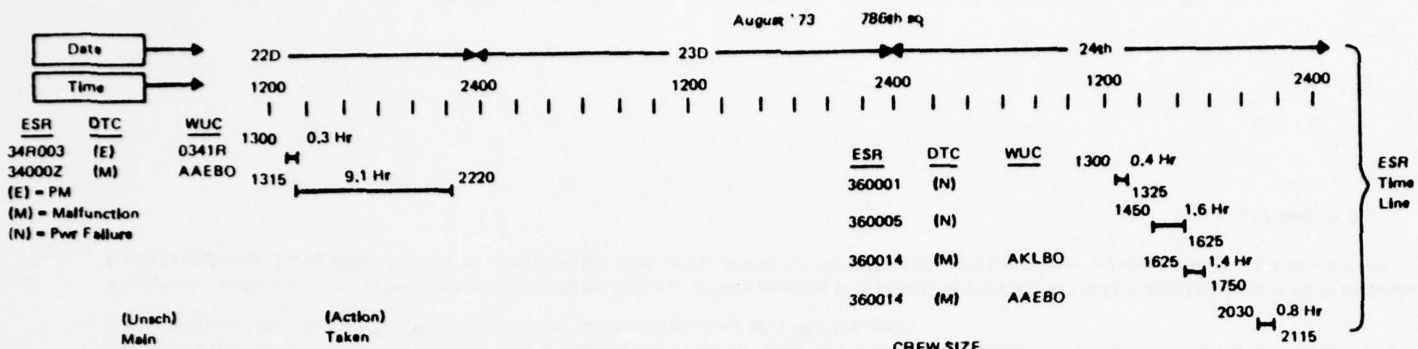
JCN	TM	WUC	AT	Hr/Tenths	D/M/Yr	Crew Size 2	3	4	5	6
200 0001	B	AKG00	Y	1.6	19073	0.8	–	0.4	–	–
			G	2.4	23073	1.2	0.8	0.6	–	0.4

The system was downed due to MALFUNCTION (M) at 1325 Hr, 19 July 1973. The Delay Code changed to "N" NORS at **1415, 50 min. later (0.8 hr).** The JCN shows TROUBLESHOOTING (Y) of 1.6 hr, representing a crew **of 2 (0.8 hrs each).**

The system continued in "N" NORS status until **1420 hr,** 23 July. It then reverted to a downtime code of "M" MALFUNCTION, until 1530 hr, when **it was brought up, 1.2 hr later.** This 1.2 hr represents the JCN time of 2.4 hr for "G" REPAIR, which indicates a 2-man crew (2 x 1.2 hr = 2.4 hr).

S77-0465-V-2

Figure A-5. ESR and Maintenance Record Correlation, Example 2



JCN	(Unsch) Main TM	WUC	(Action) Taken AT	HR/TENTHS	D/M/YR
2340002	B	AAEBO	Y	5.2	22083
	B		Y	21.5	22083
	B		L	13.2	22083
	B		R	0.3	24083
2360014	F	AKLBO	Y	2.0	24083
	F		G	0.8	
2360019	B	AAEBO	L	4.0	24083

CREW SIZE 1	2	3	4	5	6	7	8	EMT
	2.6	–	1.3	–	–	–	–	2:35
	10.7	7.2	–	4.3	–	–	–	4:20
	6.6	4.4	3.3	–	2.2	–	–	2:10
0.3	0.2	0.1						9:05 → 9.1 Hr
	0.2	–	1.0	0.8	0.7	–	0.5	

To resolve JCN 234002 and 2360019: Dates of maintenance actions are 22 and 24 Aug 1973 (22083 and 24083).

On 22 Aug system was down for PM 1300 to 1315 hrs at which time it went down for malfunction, charged to WUC AAEBO. It was down for 9.1 hr (1315 - 2220 hr) JCN 2340002 shows 2 TROUBLESHOOTING (Y) and 1 ALIGN/ADJUST (L) actions on AAEBO on 22083 date. Manipulating the crew sizes to find a combination whose sum time is 9.1 hr elapsed time, shows 2 man crew TROUBLESHOOTING for 2 hr, 35 min (2.6 Hr), a 5-man crew TROUBLESHOOTING for 4 hr,20 min (4.3 Hr) and a 6-man crew ADJUST/ALIGNING for 2 hr, 10 min (2.2 Hr). The 2 TROUBLESHOOTING entries indicate a change in crew size.

The system was brought up by 2220 hr on 22 Aug.

On 24 Aug, the system again went down, twice for power failure reported in 65-110 data under ESRs 2360001 and 2360005. No JCN's were made into the 66-1 date on these 2 downings. At 1625 a malfunction occurred causing a downing (ESR 2360014) which generated a JCN 2360014, with TYPE MAINTENANCE code "F" (Failed Flight Check), charged to WUCAKLBO. The time down (1.4 hr) can be seen to be 2 crewman TROUBLESHOOTING (Y) for 1 hr and 2 crewman REPAIRING (G) for 0.4 hr. Their labor would be 2 x 1.0 hr = 2.0 hr (Y) and 2 x 0.4 hr = 0.8 hr (G).

At 2030 hr the system again malfunctioned, charged to WUC AAEBO and was down until 2115 hr (0.8 hr). A new JCN 2340002 was initiated showing only ALIGNMENT/ADJUST time of 4.0 hr. But JCN 2340002 on WUC AAEBO shows a REMOVE/REPLACE action occurring on 24 Aug of 0.3 hr. Combining these 2 JCN's against WUC AAEBO shows probably 3 men REMOVED/REPLACED the sub-assembly in 0.1 hr (5 min) and a 6 man crew on JCN 2360019 spent 0.7 hr (40 min) ALIGN/ADJUST the subassembly/unit for a downtime of 0.6 hr.

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Figure A-6. ESR and Maintenance Record Correlation, Example 3

35 min = 0.6 hr x 3 crew = 1.8 man-hours

Others multiplied elapsed time in minutes by crew size and then converted to hours and tenths:

35 min x 3 crew = 105 min = 1.7 man-hours

The result is that where a JCN is composed of several maintenance actions and only the total system downtime is known, the number of possibilities for combining individual MA times to equal total system downtime becomes formidable (see figure A-6).

Another example, which is revealed in comparing ESR's with maintenance records, concerns the practice of deferring repair maintenance until the next scheduled maintenance downtime period. It is assumed that most, if not all, ground electronic equipment is allocated approximately 1-hour downtime per 24-hour period for scheduled (preventative) maintenance. Records reveal that some organizations troubleshoot to isolate the fault of a malfunction when it occurs and is ESR reportable but then defer the actual remove/replace or repair until the equipment is turned down for preventative maintenance. In most of these cases, it is nearly impossible to determine the actual elapsed maintenance time for the initial fault repair since it is performed during the 1-hour time slot and could be performed by 1, 2, 3, or more men on a crew. This example is an illustration of a basic assumption which appears in the reduced data of this study. It is assumed, in all cases using system downtime to break man-hours into its component of EMT and crew size, that the system is returned to an OR status within minutes of completion of adjustment/alignment or repair action. The following is an example:

The system is down for 2 hours. After the first 20 minutes, its status changes to a NORS Delay code and it remains NORS for 1 hour. It then reverts to a downtime code for malfunction for the final 40 minutes until it is OR. If it is assumed that the repair action on the maintenance form, which is 2.0-hr labor (120 min), is performed during the last 40 minutes, then the crew size could be 3 men for 40 minutes (for 120 minutes labor)

or 4 men for 30 minutes (for 120 minutes labor) or 6 men for 20 minutes (120 minutes labor). The assumption is made in the data reduction that 3 men would be used for 40 minutes with the system becoming OR immediately upon completion. The possibility that 4 men would be used for 30 minutes leaves 10 minutes unaccounted for and defeats the aim of returning the system to an OR status as soon as possible. Therefore, crew size is assumed to be that number of men which when multiplied by EMT (either in increments of 5 minutes or in tenths of hours) most nearly equals the applicable portion ofdowntime.

Another assumption made in the analysis of data to obtain EMT is that when an ESR report indicates that a NORS delay becomes the primary cause for downtime, it is assumed that the troubleshooting action of maintenance has been completed. With completion of troubleshooting, the faulty subsystem/assembly/component has been identified, and the need for a part made known to supply. This rationale does not hold in all cases since instances will occur where troubleshooting will continue in search of a secondary failure. However, most of the records indicate these instances are relatively few, and other indications are present when it does occur: a separate troubleshoot maintenance action; a change of crew size in troubleshooting; an excessively long period of troubleshooting coincident with a NORS status change; and different WUC's for remove or repair actions.

The field data summaries present the results of reducing the maintenance records available for this study to the critical parameter of EMT for each maintenance action recorded. For the four systems selected for analysis of records, different squadrons were chosen mainly on the basis of total maintenance records available over the 1-year period. Total records contained in the ADC printouts were screened to eliminate off-equipment maintenance, all maintenance except unscheduled, and duplicate records. These remaining records were then correlated with the ESR printouts to ascertain EMT. For some systems, due to the small quantity of maintenance records, the number of squadrons evaluated was increased.

Equipment	No. of Squadrons Evaluated
AN/FPS-27A	7
AN/FYQ-47	10
AN/GPA-124	32
AN/GPA-127	20

The field data summaries show for each system and for each squadron the number of On-Equipment maintenance records (unscheduled maintenance) over the 1-year period and the number of these records which, after analysis had an elapsed maintenance time assigned.

Correlation of the maintenance records with the associated ERS reports, a difficult and time-consuming task, is not the primary purposes of this study. It was an initial task to produce the main parameters needed for further analysis. Consideration was given to attempting to program a computer solution to derive EMT for each maintenance record. The program was discarded, however, for reasons of time, economy, the need for assumptions to be based on variable rather than constants, the necessity to cardpunch the ESR reports in total, and the experimental nature of the correlation process which varies depending on the squadron. In fact, during the course of studying documentation, records, and cardpunch/taping procedures used with the MDC system, evidence was found that records already existed containing EMT data. This data may only be at each base level where the AFTO Form 349 is initially cardpunched and accumulated on tapes; but it is reflected in a formatted tape record (ABDB4A and ABDM9A) illustrated in AFM 66-267, Maintenance Data Collection System, and appears in card columns above 105. Retrieval of this data may require utilization of the base level inquiry system (BLIS) and would have to be performed on a site-by-site basis to obtain all squadron's data.

A.3 PRESENTATION OF DATA

Following correlation of the record and identification of EMT's for all possible maintenance actions, an analysis was performed. Maintenance was grouped to the lowest assembly or component of the equipment by the WUC

on the record, The essential parameters off the records were listed (along with the JCN number for later reference purposes) and tabulated against the particular equipment's WUC. This gave a certain visibility to the types of maintenance actions performed and the elapsed time required for their performance. Records were segregated to the lowest assembly level as identified by the WUC, and then in steps, consolidated to the highest level.

Since 100 percent of the records were not available for study, subsequent analysis is recognized to have the following limitations.

a. Records used are not the total which may have been generated. ESR reports indicated many JCN's assigned which were not included in MDC printouts and a system malfunction with a JCN assigned which was coded as scheduled maintenance or special inspection.

b. All MA's for a particular JCN may not have had an EMT established because of problems in time correlation, probable errors in cardpunch, or data lost/missing in the system.

c. WUC identified on some records found to be probable typographical errors.

d. Some records assumed to be duplicates and consequently eliminated may have been two identical legitimate entries.

e. Estimating errors or biases in deriving EMT's.

Tabulation of maintenance actions were first consolidated at the lowest significant WUC levels for on-equipment maintenance. Elapsed maintenance times have been summed to this level to include all times spent in trouble-shooting, repair, remove and replace, adjust/align, and clean. Each discrete JCN, as assigned to a maintenance task which is generated by a system failure/malfunction, is considered a separate system fault. Therefore, by totaling maintenance elapsed times and dividing by number of discrete JCN's an average time is derived for each failure correction:

$$\overline{M}_{ct} = \frac{\Sigma \, EMT}{\Sigma \, failures} \qquad (A-6)$$

where

$\overline{M}_{ct}$ = mean corrective maintenance time

Table 4.1.2 is a composite summary of some of this data.

Table A-1 is an example of the composite listing of all the Air Force dated collected and evaluated as part of this study. Illustrated in this table is the job can be numbers (JON's) and the Work Unit Code (WUC) associated with each maintenance action. Also shown are the man-maintenance hours (mmh), the elapsed time and the malfunction code for each action. Additionally, the crew size for each maintenance action is indicated. Where this was impossible to derive, a question mark was placed.

A.4 MAINTENANCE CODES

A.4.1 Communication - Electronics - Meteorological Codes

Definition of these codes are contained in the following pages.

1. *Title:* Action Taken — Maintenance, ADE AC--780, Chg Eff: 1 Sep. 69
2. *Data Name:* ACTN-TAKEN-MAINT
3. *Definition/Explanation:* Action Taken codes used in conjunction with work unit codes, how malfunctioned codes, and when discovered codes, identify a complete unit of work, a maintenance task or action. This code describes the action taken to clear the equipment malfunction (bench checked & repaired, condemned, remove & replace, trouble shoot, corrosion treatment, etc.)
4. *Data Use Identifier and Explanation:*

	4a. *Data Name*	4b. *Code Size and Class*
Action Taken — Maintenance — See 3 above	ACTN-TAKEN-MAINT	1AN
Number Items for Each Action Taken The number of items for each Action Taken Code submitted on an Unsatisfactory Report	NR-ACT-TAKEN	3N Literal

5. *Data Items and Explanations*	*Item Data Name*	*Data Codes*
Bench Check and Repaired—Bench check and repair of any one item is accomplished at the same time. (Also see Code F.)	BNCH-CHK-AND-RPRD	A
Bench Checked—Serviceable (No Repaired Required)—Item is bench checked and no repair is required.	BNCH-CHK-SVRCBL	B
Bench Checked—Repair Deferred—Bench check is accomplished and repair action is deferred. (See Code F.)	BNCH-CHK-RPR-DFRD	C
Bench Checked—Transferred to Another Base or Unit—Item is bench checked at a forward operating base, dispersed operating base or enroute base and is found unserviceable and transferred to a main operating base or home base for repair. This code will not be used for items returned to a depot for overhaul. This code will also be used when PME or other equipment is sent to another base or unit for bench check, calibration, or repair and is to be returned; and for items forwarded to contractors on base level contracts.	BNCH-CHK-TRANSFRD-BASE	D
Bench Checked—NRTS (Not Repairable This Station—Repair Not Authorized—Shop is not authorized to accomplish the repair. This code shall only be used when the repair required to return an item to serviceable status is specifically prohibited by current technical directives. This code shall not be used due to lack of authority for equipment, tools, facilities, skills, parts or technical data.	BNCH-CHK-NRTS-NOT-AUTHD	1
Bench Checked—NRTS—Lack of Equipment, Tools, or Facilities—Repair is authorized but cannot be accomplished due lack of equipment, tools, or facilities. This code shall be used without regard as to whether the equipment, tools, or facilities are authorized or unauthorized.	BNCH-CHK-NRTS-EQP-TL-FCL	2
Bench Checked—NRTS—Lack of Technical Skills—Repair cannot be accomplished due to lack of technically qualified people.	BNCH-CHK-LCK-TCHNCL-SKLS	3
Bench Checked—NRTS—Lack of Parts—Parts are not available to accomplish repair.	BNCH-CHK-NRTS-LCK-PTS	4
Bench Checked—NRTS—Shop Backlog—Repair cannot be accomplished due to excessive shop backlog.	BNCH-CHK-NRTS-SHOP-BCKLG	5
Bench Checked—NRTS—Lack of Technical Data—Repair cannot be accomplished due to lack of maintenance manuals, drawings, etc., which describe detailed repair procedures and requirements.	BNCH-CHK-NRTS-LCK-TCHNCL	6
Bench Checked—NRTS—Excess to Base Requirements—Repair will not be scheduled for shop repair due to item being excess to base requirements.	BNCH-CHK-NRTS EXCS-REQMT	7

1. *Title:* Action Taken—Maintenance, ADE AC-780, Chg Eff: 1 Sep 69 (Continued)

5. *Data Items and Explanations* (Continued)	*Item Data Name*	*Data Codes*
Bench Checked—Return to Depot—Returned to Depots by direction of System Manager (SM) or Item Manager (IM). Use only when items that are authorized for base level repair are directed to be returned to depot facilities by specific written or verbal communication from the IM or SM, or when items are to be returned to depot facilities for modification in accordance with a Time Compliance Technical Order (TCTO), or as UR exhibits.	BNCH-CHK-RETN-DEPOT	8
Bench—Checked—Condemned—Item cannot be repaired and is to be processed for condemnation, reclamation or salvage. This code will also be used when a "condemned" condition is discovered during field maintenance disassembly or repair.	BNCH-CHK-CNDMND	9
Initial Installation—For installation actions that are not related to a previous removal action such as installation of additional equipment or installation of an item to remedy a ship-short condition. This code will be used only for equipment managed under the Advanced Configuration Management System. Reference T.O.'s 00-20-2-3, 00-20-2-5, and 00-20-2-7. Must be used with How Mal Code 799.	INIT-INSTLN	E
Repair—Not to be used to code "on-equipment" work if another code will apply. When it is used in a shop environment, this code will denote repair as a separate unit of work after a bench check. Shop repair includes the total repair manhours and includes cleaning, disassembly, inspection, adjustment, reassembly and lubrication of minor components incident to the repair when these services are performed by the same work center. For precision measurements equipment, this code will be used only when calibration of the repaired item is required (see code G).	RPR	F
Repairs and/or Replacement of Minor Parts, Hardware and Softgoods (Seals, Gaskets, Electrical Connectors, Fittings, Tubing, Hose, Wiring, Fasteners, Vibration Isolators, Brackets, etc.) — Work unit codes do not cover most non-repairable items. Therefore, when items such as those identified above are repaired or replaced, this action taken code will be used. When this action taken code is used, the work unit code will identify the assembly being serviced or most directly related to parts being repaired or replaced. For example, if an electrical connector was repaired and was attached to a radio transmitter, the work unit code for the transmitter would be used with this action taken code. For precision measurement equipment this code will be used for repairs that do not require calibration of the repaired item (see code F).	RPR-RPLCMT-MNR-PTS-HDWR	G
Equipment Checked—No Repair Required (for "on-equipment" work only—All discrepancies which are checked and found to require no further maintenance action. This code will be used only if it is definitely determined that a reported deficiency does not exist or cannot be duplicated. Must be used with How Mal Code 799, 812, or 948.	EQMPT-CHK-NO-	H

1. *Title:* Action Taken—Maintenance, ADE AC-780, Chg Eff: 1 Feb 70 (Continued)

5. *Data Items and Explanations* (Continued)	*Item Data Name*	*Data Codes*
Calibrated—No Adjustment Required—Use this code when an item is calibrated and found serviceable without need for adjustment, or is found to be in tolerance but is adjusted merely to peak or maximize the reading. If the item requires adjustment to actually meet calibration standards or to bring in tolerance, use Code K.	CLBRTD-NO-ADJSTMT-RQRD	J
Calibrated—Adjustment Required—Item must be adjusted to bring it in tolerance or meet calibration standards. If the item was repaired or needs repair in addition to calibration and adjustment, use Code F.	CLBRTD-ADJSTMT-RQRD	K
Adjust—Includes tighten, adjust, bleed, balance, rig, and fit, or actuating reset button or switch.—A particular discrepancy is cleared by adjusting, etc., the item. If the identified component also requires replacement bits and pieces as well as adjustment (new points, condensers, tubes, etc.) enter the appropriate repair code instead of L.	ADJST	L
Disassemble—Disassembly action when the complete maintenance job is broken into parts and reported as such. Do not use for on-equipment work.	DISMBL	M
Assemble—Assembly action when the complete maintenance job is broken into parts and reported as such. Do not use for on-equipment work.	ASMBL	N
Removed—Item is removed and only the removal is to be accounted for. In this instance delayed or additional actions will be accounted for separately. (Also see codes Q, R, S, T, and U.) Do not use for off-equipment work.	RMVD	P
Installed—Item is installed and only the installation action is to ⇒be accounted for. (Also see codes, E, P, R, S, T, and U.) Do not use for off-equipment work.	INSTLD	Q
Remove and Replace—Item is removed and another like item is installed. (Also see codes T and U.) Do not use for off-equipment work.	REMV-AND-RPLCD	R
Remove and Reinstall—Item is removed and the same item reinstalled. (Also see codes T and U.) Do not use for off-equipment work. Must be used with How Mal Code 800, 804 or 805.	REMV-REINSTL	S
Removed for Cannibalization—A component is cannibalized. The work unit code will identify the component being cannibalized. Do not use this code for off-equipment work. Must be used with How Mal Code 799.	REMV-FR-CNBLZTN	T
Replaced After Cannibalization—This code will be entered when a component is replaced after cannibalization. Do not use this code of off-equipment work. Must be used with How Mal Code 799.	RPLCD-AFTR-CNBLTZN	U
Clean—Cleaning is accomplished to correct discrepancy and/or when cleaning is not accounted for as part of a repair action such as code F. Includes washing, acid bath, buffing, sand blasting, degreasing, decontamination, etc. Cleaning and washing of complete items such as ground equipment, vehicles, missiles or airplanes should be recorded by utilizing support general codes.	CLEAN	V

1. *Title: Action Taken—Maintenance. ADE AC-780. Chg Eff: 1 Sep 69 (Continued)*

5. *Data Items and Explanations* (Continued)	*Item Data Name*	*Data Codes*
Test-Inspection-Service—Item is tested or inspected or serviced (other than bench check) and no repair is required. This code does not include servicing or inspection chargeable to support general work unit codes.	TEST-INSPCT-SERVICE	X
Troubleshoot—Time expended in locating a discrepancy is great enough to warrant separating the troubleshoot time from the repair time. Use of this code necessitates completion of two separate line entries, or two separate forms, one for the troubleshoot phase and one for the repair phase. When recording the troubleshoot time separate from the repair time, the total time taken to isolate the primary cause of the discrepancy should be recorded utilizing the work unit code of the defective sub-system or system. Do not use for off-equipment work.	TRUBLSHOOT	Y
Corrosion Repair—Includes cleaning, treating, priming and painting of corroded items. This code should always be used when actually treating corroded items, either on equipment or in the shop. The work unit code should identify the item that is corroded. Use support general code for painting or corrosion preventive treatment prior to an item becoming corroded.	CROSION-RPR	Z

1. *Title:* Maintenance—Type Maintenance Designators, ADE MA-358, Chg Eff: 1 Apr 70
2. *Data Name:* MNTNC—TYPE
3. *Definition/Explanation:* Identifies the type of work that is performed (formerly was the second position of the work order prefix).
4. *Data Use Identifier and Explanation:*

	4a. *Data Name*	4b. *Code Size and Class*
	MNTNC-TYPE	1A

5. *Data Items and Explanations* — *Data Codes*

Type maintenance is a one digit element. This element was formerly the 2nd position of the work order prefix. Denote type of work performed.

(2) Type maintenance codes for Ground C-E-M, COMSEC and ground C-E-M "L" systems (except ground launched missile C-E-M).

Description	Data Codes
Service—Includes all units of work associated with servicing, cleaning, (not part of a PMI), movement of equipment, ground safety monitors not actually assisting in the maintenance task, and preparation of records (excluding AFTO 349 and 350). *Examples:* Setting up mobile communication facilities; initial installation or relocation of telephone instruments and key systems; etc.	A
Unscheduled Maintenance—Includes all unscheduled units of repair work authorized and accomplished between scheduled inspections. Does not include the look or fix phase of inspectionor routines, or work covered by Type Maintenance codes R or T.	B
Scheduled Inspection Daily/Shift—Includes all units of work authorized while accomplishing daily/shift inspections. ⇒ This code will also be used on all separate "fix" or "repair" documents generated for the purpose or recording the correction of deficiencies noted during the inspection.	D
⇒Scheduled Inspection—Phased/Periodic—Includes all units of work authorized while accomplishing phased/periodic inspections. ⇒ This code will be used on all separate "fix" or "repair" documents generated for the purpose of recording the correction of deficiences noted during the inspection: *NOTE:* Accomplishment of unscheduled routines performed as part of a repair will be considered part of the total repair action; i.e., action taken code G, F, etc. Type Maintenance D and F should be used only for scheduled inspections or routines as defined above.	F
Calibration of Operational Equipment (Non PME) by Owning or Assisting Work Center —Excludes calibration actions by PME calibrating work centers (see paragraph (3) for Type Maintenance codes for PME).	J
Emergency On-Site Repair—Includes all units of repair work authorized and accomplished as a result of an emergency request for assistance. Applicable to MDA and GEEIA only. Excludes accomplishment of TCTO's.	H
Scheduled Maintenance—Includes all scheduled units or repair work authorized and accomplished between scheduled inspections, such as periodic scheduling of equipment through the shops. Excludes the "look" and "fix" phase of scheduled PMI routines and special inspections, and work outlined in Type Maintenance codes B, R, T, and W.	P
Depot Maintenance—Includes all units of work accomplished when depot maintenance is performed regardless of location. This code also includes installation or rehabilitation of equipment and includes accomplishment of TCTO's and emergency on-site repair as defined in code H.	R
Special Inspection—Includes all unit of work accomplished during special inspections. This code will also be used for all separate "fix" or "repair" documents generated for the purpose of recording the correction of deficiences noted during the special inspection.	S
Time Compliance Technical Order (TCTO)—Includes accomplishment of all TCTO's.	T
Reclamation—Includes reclamation of complete end items such as AN/FPS-6 radar.	U

1. *Title:* When Discovered Designators (Ground CEM, Trainers, AGE and Vehicles), ADE WH-180, Chg Eff: 1 Feb 69.
2. *Data Name:* WHEN-DISCVD-GND
3. *Definition/Explanation:* Indicates when a need for maintenance was discovered (During Operation, Inspection, Quality Control check, etc.)
4. *Data Use Identifier and Explanation:*

4. Data Use Identifier and Explanation	4a. *Data Name*	4b. *Code Size and Class*
When Discovered Designators (Ground CEM, Trainers, AGE and Vehicles)	WHEN-DISCVD-GND	1A

GROUND C-E-M, TRAINERS, AGE AND VEHICLES

Code

C. During Equipment Operation/Caused Equipment Down Time.

D. During Equipment Operation/Did Not Cause Equipment Down Time.

E.

F. Unscheduled Maintenance.

G. Scheduled Inspection C-E-M Type I PMI.

H. Scheduled Inspection C-E-M (Phased or Periodic).

J. Daily Inspection/Shift Verification.

K. Scheduled Inspection C-E-M Type 3 PMI.

L. During Training or Maintenance on Equipment Utilized in a Training Environment (Use only for Class II Training Equipment). This code should be used when recording maintenance or discrepancies on Class II trainers.

M. Scheduled Inspection (not CEM).

P. Operational Systems Check.

Q. Special Inspection.

R. Quality Control Check.

S. Depot Level Maintenance.

T. During Scheduled Calibration.

U. Non-Destructive Inspection. Includes optical, penetrant, magnetic particle, radiographic, eddy current, ultrasonic, spectrometric oil analysis, etc.

V. During Unscheduled Calibration.

W. In-Shop Repair and/or Disassembly for Maintenance.

Y. Upon Receipt or Withdrawal from Supply Stocks.

Z. During Initial Equipment Installation.

A.4.2 Downtime and Delay Codes

Definitions of these codes are contained in the following pages.

1. *Title:* Down Time, ADE DO-910, Chg Eff: 1 Jan 70
2. *Data Name:* DOWN-TIME
3. *Definition/Explanation:* Used to identify the reason CEM is not operational.
4. *Data Use Identifier and Explanation:*

	4a. *Data Name*	4b. *Code Size and Class*
Down Time—See 3 above	DOWN-TIME	1A

5. *Data Items and Explanations*

	Data Codes
Retrofit or Modification—Used when it is necessary for an operational command to remove an active equipment from its assigned mission to perform a modification.	A
Depot Maintenance Scheduled—Those periods that the equipment is not operational due to scheduled Air Materiel Area (AMA) overhaul, radome painting, etc., to the C-E-M equipment/channel (not technical assistance).	B
Test (Orientation, etc.)—That time the C-E-M equipment/channel is not active in its assigned mission due to scheduled operational test.	C
Retrofit or Modification—Used when it is necessary for AFLC to remove an active equipment from its assigned mission to perform a modification.	D
Preventive Maintenance—That time the C-E-M equipment/channel is not active in its assigned mission due to performance of scheduled inspection(s). Preventive Maintenance Instructions required by -6 technical orders/work cards.	E
NOTE: In the absence of USAF published PMI's, this will include command devised and required PMI's.	
⇒Failed Flight Check or Operational Systems Check—Used to record that time an active equipment is not capable of performing its assigned mission due to inability to pass ⇒flight inspection or periodic operational system checks.	F
Vehicle out of Commission—Used when a vehicle which is an integral part of a CEM system is out of commission and the CEM equipment is fully operational.	G
Host Base Action—Used to record that time equipment is not performing its assigned mission due to reasons such as runway construction, building repair, snow removal, etc.	H
Damage or Deterioration—Use to record that time an active equipment is not performing its assigned mission due to uncontrollable equipment damage including battle damage or deterioration which is not the result of equipment malfunction and is beyond the maintenance activities control; Examples are: natural disasters, vandalsim, riot, and factors affecting propagation not covered by Codes W or X.	J
Relocating/Resiting—Used to record that time an active equipment is not performing its assigned mission due to relocating and/or resiting of equipment for any reason.	K
NOTE: Not applicable to Tactical Deployment of Ground CEM equipment.	
Associated Equipment Malfunction—Used when associated or ancillary equipment has caused downtime of the reported end item.	L
Equipment Malfunction—That time the equipment/channel is not capable of performing its assigned mission due to component failure or maladjustment.	M
Power Failure—That time the equipment/channel is not capable of performing the assigned mission due to lack of commercial or local primary/secondary power or unstable power source. Time charged against this code will include all recovery time expended as a result of the power failure.	N

1. *Title:* Down Time, ADE DO-910, Chg Eff: 1 Nov 67 (Continued)

5. *Data Items and Explanations*

	Data Codes
Environment Control—Used when the equipment cannot perform its assign mission due to failure or malfunction of temperature/humidity/dust control equipment.	P
Cable Out—Used to record that time an active equipment/channel cannot perform its assigned mission due to defective or cut cable.	Q
Emergency Maintenance—Those periods that the equipment is not meeting technical order standards, and outside assistance is requested. This code is assigned at the time it is determined asistance is required and will normally required a delay code until maintenance is actually being performed on the equipment.	R
Scheduled Power Change/Outage—Used when the equipment/channel is not capable of performing the assigned mission due to loss of source power (commercial local) caused by scheduled power change or scheduled power outage.	S
Training—Used when the equipment/channel cannot perform the assigned mission due to on-the-job training as approved by the Approving Authority.	T
Unknown—Used, when required, for initial reporting of suspected equipment failure or malfunction prior to determination of the actual cause and for equipment failure or malfunctions that are self-corrected. This code will be used only when absolutely no other DTS will explain the equipment outage.	U
Military Priority—Used only when equipment must be shut down due to personnel safety hazard, interference with another equipment or system, or when directed by a higher command, i.e., interference with X-15 flights, missile firing, etc.	V
Atmospheric Disturbance or Weather—Used when equipment cannot perform its intended mission due to severe weather or atmospheric conditions such as anamalous propagation, high winds, heavy snow, or icing, etc. An ESR card is required only on the equipment directly affected. Example, downtime caused by icing on an FPS-18 antenna requires an ESR only on the FPS-18 and not on the FSW-1, FST-1, TD-285, etc.	W
Jamming—Intentional/Nonintentional—Used when a radar and/or communications facility is experiencing interference, regardless of its origin.	X
Personnel or Program Error—Those periods the equipment is not performing its assigned mission due to operator, maintenance or programmer error. Example, incorrect switch or button activation, error in computer programming, downtime for a reported failure, or malfunction when an investigation reveals that a failure or malfunction did not occur, etc.	Y
Frequency Change—Used when equipment is not performing its assigned mission due to authorized frequency change actions.	Z

1. *Title:* Maintenance Delay, ADE MA-300, Chg Eff: 1 Jun 68
2. *Data Name:* DELAY
3. *Definition/Explanation:* Used to identify the types of delay or delays encountered in returning CEM to an operational status.
4. *Data Use Identifier and Explanation:*

	4a. *Data Name*	4b. *Code Size and Class*
Maintenance Delay—See 3 above	DELAY	1A

5. *Data Items and Explanations*

	Data Codes
Single Shift Maintenance—Used when an equipment or a channel of an equipment has malfunctioned, and personnel are not available for corrective action because of the single shift maintenance concept.	A
Awaiting Flight Check—Used when all maintenance tasks have been accomplished and an official flight check has been requested, however, equipment cannot be considered operational due to lack of flight check certification. Time recorded under this DC terminates when an official certification flight check starts.	B
Awaiting Technical Assistance (Command)—Used when technical assistance has been requested from any parent or lateral activity within the parent command. Time recorded under this delay code terminates when assistance arrives on site.	C
Awaiting Technical Assistance (AFLC)—Used when technical assistance has been requested from an AFLC activity. Time recorded under this delay code terminates when assistance arrives on site.	D
Awaiting Technical Assistance (contractor)—Used when the CEM end item is specified to be supported by a contractor and technical assistance has been requested. Time recorded under this delay code terminates when the assistance arrives on site.	E
Flight Check—Used to record the time required to perform an official certification flight check.	F
Awaiting System Check—Used when awaiting quality control check, post-deployment inspection, or initial check-out, other than flight check, upon initial receipt of equipment into the inventory or resiting.	G
Not Operational Ready Supply (Initial Provisioning)—This code used when DOD procured equipment, other than commercial off-the-shelf equipment, is possessed by an operational unit is primary mission equipment and which is non-operational ready and cannot be returned to readiness, or cannot be deployed or activated, due to a lack of initial or operational spares.	J
Off-Site Maintenance—Used when it has been determined that it would expedite return of an equipment to an operational status by using off-base maintenance activities to repair or fabricate a part and delay codes M and N are not applicable. This determination will be made by the maintenance control officer or chief of maintenance.	K
Not Operationally Ready Supply, DSA—Used to identify those supply delays directly attributable to supply items for which management responsibility rests with the Defense Supply Agency (DSA).	L
Not Operational Ready Supply (Depot—NORS)—Used when the Ground C-E-M equipment is delcared NORS by the Chief of Maintenance, the required part is not available at the base or from the CSS and must be obtained from the appropriate AFLC Depot. (Column 59 will not be coded until determination has been made by Materiel Control that the part is not available at the CSS). In the event of simultaneous requirements for parts to be furnished by both the CSS, Depot, etc., this code will have precedence. When a part is obtained through Lateral Support, this original delay code will not be changed. Reference para 1C, AFR 67-95. The starting time will be that time when the NORS condition was initially established. The NORS condition will cease immediately when the requirement for the part is cancelled or the required item or items are received at the site.	M

1. *Title:* Maintenance Delay, ADE MA-300, Chg Eff: 1 Jun 68 (Continued)

5. *Data Items and Explanations* — *Data Codes*

Explanation	Data Codes
Not Operational Ready Supply (Command Supply Agency—NORS)—Used when the Ground C-E-M equipment is declared NORS by the chief of Maintenance and the required part is available at the CSS. (Column 59 will not be coded until determination has been made by System Materiel Control that the part(s) is available at the CSS). The starting time will be that time when the NORS condition was initially established. The NORS condition will cease immediately when the requirement for the part is cancelled or the required item or items are received at the site.	N
Not Operational Ready Supply (Other Supply Action—NORS)—Used when the Ground C-E equipment is declared NORS by the Chief of Maintenance and the part required is obtained from any source other than through the CSS or AFLC/DSA Depot, e.g., local purchase thru petty cash, etc. (Column 59 will not be coded until determination has been made by Materiel Control that the parts will be obtained from a source other than through CSS or Depot). The starting time will be that time when the NORS condition was initially established. The NORs condition will cease immediately when the requirement for the part is cancelled or the required item or items are received at the site.	P
Not Operational Ready Supply (Non-DOD)—Used when a unit is possessed, primary mission equipment is not operational ready supply, and the equipment is supply supported by a non-DOD activity; i.e., FAA, or by a foreign government or military establishment.	Q
Not Operational Ready Supply (Contractor Support—NORS)—Used when the Ground C-E-M equipment is delcared NORS by the Chief of Maintenance and the C-E-M end item is specified to be supported by a contractor, i.e., AN/FSQ-7.	R
Skill Not Available—Used when qualified maintenance personnel are not available to perform the required field/organizational level maintenance.	S
Travel Time—Used when maintenance delay is caused by travel between the maintenance organization to a remote facility that has malfunctioned.	T
Tools, Test Equipment and Technical Data Not Available—Used when the tools, test equipment or technical data required to adequately accomplish the maintenance task are not available at the maintenance organization.	U
Military Priority—Used when restoration of equipment to operational status is prevented by directive from higher military authority. Enter the directing authority in the "Remarks" section of AF Form	V
Delay for Weather—Used when equipment cannot be restored to operational status for any reason attributable to weather conditions.	W
Awaiting Transportation—Used when a delay is caused while awaiting transportation to the maintenance job location.	X
Not operational Ready Supply (Supply Delivery Time)—Used when parts or equipment required to terminate a previously established NORS condition are in transit from the supply activity.	Y
Other—Used when a delay is encountered in restoring the equipment to operational status and the delay although known, is not covered by any other delay code. Use of this code will be fully explained in the "Remarks" section of the card (AF Form 182.).	Z

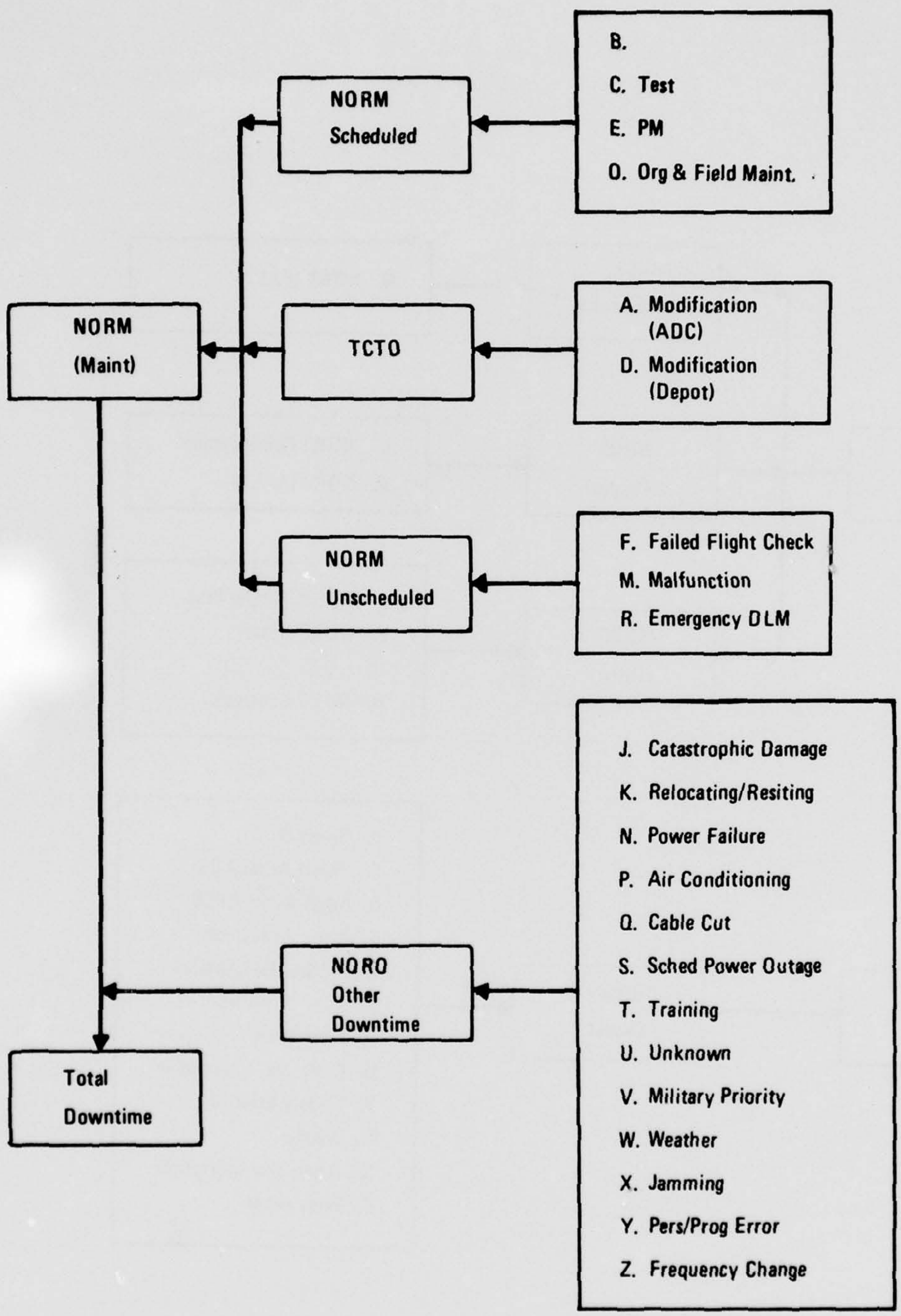

Figure 4-3. Downtime Code Summary Logic Table

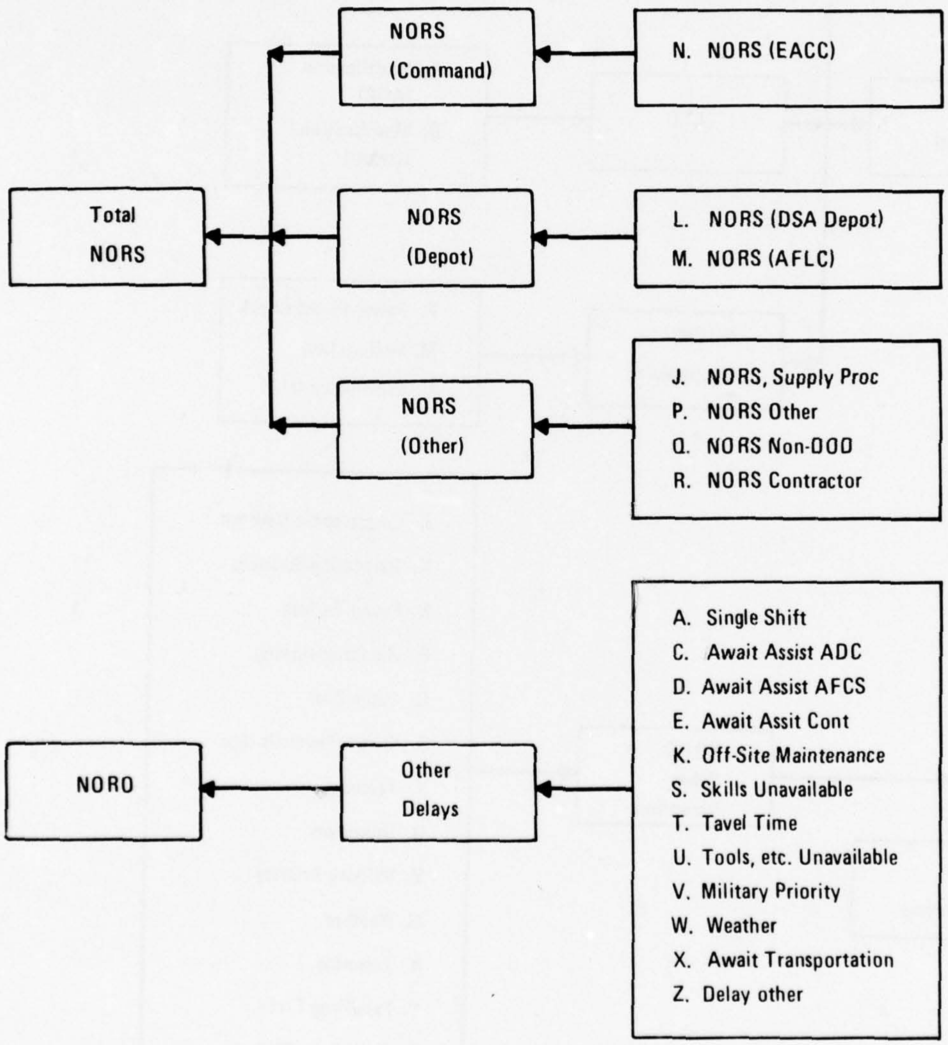

Figure 4-4. Delay Code Summary Logic Table

	AF						AC						AJ						G						AF					
WUC	JCN	AT	MAL	MMH	Est Crew	Elaps Time	JCN	AT	MAL	MMH	Est Crew	Elaps Time	JCN	AT	MAL	MMH	Est Crew	Elaps Time	JCN	AT	MAL	MMH	Est Crew	Elaps Time	JCN	AT	MAL	MMH	Est Crew	Elaps Time
B00	3100001	Y	583	9.0	3	3.0	3170001	Y	649	1.0	2	0.5	3301001	G	692	2.0	2								3098008	Y	583	0.2	1	0.2
	3100001	L	127	6.0	3	2.0	3260001	Y	230	2.6	2	1.3	1190003	Y	583	2.0	4	0.5							3108008	Y	583	0.2	1	0.2
	3320503	Y	649	0.6	2								1190003	Y	583	3.0	3	1.0							1308002	Y	583	0.5	1	0.5
	1540046	G	583	0.5	2	0.3							1190003	Y	583	13.0	2	6.5							1308002	G	583	0.4	1	0.4
													1200003	Y	583	3.5	1	3.5							1308002	L	583	0.5	1	0.5
													1200551	Y	583	0.8	2	0.4							1680888	Y	583	1.0	1	1.0
													1340007	Y	583	6.5	2	3.3							1680888	G	583	8.8	2	4.4
													1340007	G	583	1.0	2	0.5												
													1410010	Y	583	2.5	2													
													1410010	G	583	2.5	2													
													1786000	Y	255	2.0	2													
													1786000	Y	255	3.0	2													
BA0							341A274	R	008	1.0	2		2821002	G	583	0.5	2		1752015	G	255	6.0	2	3.0	3478004	G	070	1.2	2	0.6
													1200551	V	230	0.7	1	0.7												
BB0	0570001	Y	649	0.2	1	0.2	2960001	G	472	0.3	1	0.3	3201001	Y	583	1.3	2		0461005	L	255	1.0	1	1.0	2948006	G	649	1.0	2	
	0570001	Y	649	0.5	1	0.5	3100002	Y	315	1.4	2	0.7	3201001	L	583	0.2	2		0651003	L	127	0.3	2	0.2	3028005	Y	649	9.1	2	
	0570001	G	649	0.1	1	0.1	3100002	L	127	0.6	2	0.3	3201001	G	533	0.3	2		1101002	Y	649	3.5	3	1.2	3023005	G	649	1.0	2	
	0570001	G	649	0.3	2	0.2	3170001	G	649	0.5	2	0.3	3281001	G	255	0.3	2		1101002	G	649	1.0	2	0.5	2308003	G	583	7.8	2	
	1180009	G	583	0.5	1	0.5	3250001	Y	649	3.4	2	1.7	3381001	G	255	3.0	2		1361001	G	649	1.5	3	0.5	3098008	G	255	0.3	1	0.3
	1230009	L	583	0.3	2	0.2	3250001	G	649	0.6	2	0.3	3411002	L	127	1.0	2								3108004	G	649	0.1	1	0.1
							3250002	L	127	2.4	1	2.4	1290005	Y	583	0.8	2								3108004	L	127	0.2	2	
							3250003	L	127	2.6	2	1.3	1290005	Y	533	2.0	2								3108004	L	127	0.1	1	0.1
							3470001	Y	255	2.4	2	1.2	1290005	G	583	1.0	2								3103004	G	649	0.3	2	
							3470001	G	255	0.4	2	0.2	1400009	L	127	0.5	Z	0.3							3108008	G	255	0.1	1	0.1

System AN/GPA-127 - Period 1 Oct. '73 to 30 June '74

APPENDIX B

Westinghouse Field Questionnaires and Remarks

This Appendix summarizes the field questionnaire and the comments made by the Air Force technicians with regards to our questions.

1.1 Are all failures reported on 349 forms?

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	5		2			2					2									
B	2	1				3					1	1					1	1		
C	1	3				2					2					2				
D	6					1					1					2				
E	1	2				1	1				2					2				
F	1	1				1	2									1	1	1		
G	1	2				2					3					1	1			
TOTAL	17	9	2			12	3				11	1				8	3	2		

1.2 Are failures grouped when reported or are they fixed and reported individually (as they occur)?

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	4	2	1			1					2									
B	2					3					1					2				
C	3			1		2					1	1				1	1			
D	6					1					1					1	1			
E	3					1					2						2			
F	1	1				3										2	1			
G	2	1				2					1	2				1		1		
TOTAL	21	4	1	1		13					8	3				7	5	1		

1.3 Are failures fixed in periods of preventative maintenance?

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	1	3	1	1	1		1		1				1	1						
B	1	1	1					1	1				1	1			1	1		
C		2		1		1				1	1				1			1		1
D		1	2	2	1				1						1		1	1		
E			2		1				1	1					2				2	
F			1	1			1	2									1	2		
G		1	2						1					2	1		1	1		
TOTAL	2	8	9	5	3	1	2	3	5	2	1		2	4	5		4	6	2	1

1.1 Are all failures reported on 349 forms?

FPS-27A

C-1 Minor adjustments and fixes with short maintenance times are not reported.
C-2 Except light bulbs.
G-1 Problems cleared by front panel alignment are not.
G-2 Most failures with parts replaced are reported. Over 50% failures requiring only minor adjustment probably are not reported.

GPA-127

F-1 Many failures cause time loss of less than 3 minutes and require no JCN.
G-1 Exception is when P.P.I. kicks off and resetting circuit breaker is all that is required to fix.

1.2 Are failures grouped when reported or are they fixed and reported individually (as they occur)?

FPS-27A

B-1 Ambiguous question.
C-1 Minor adjustments and replacements are grouped, extensive adjustments and/or repairs are reported separately.
C-2 Grouped failures have failed parts listed separately.

FYQ-47

C-1 Failures are fixed and reported individually
E-1 Reported individually.
G-1 Have experienced no group failures.

GPA-127

B-1 Very poor question.
G-1 Failures are reported per scope.

1.3 Are failures fixed in periods of preventative maintenance?

FPS-27A

A-1 So long as they don't cause a serious outage.
C-1 Discrepancies noted during PM are usually fixed then.
D-1 Problems not affecting overall equipment performance and held for Q inspection.
D-2 Where problems don't affect overall equipment performance.
E-1 Whenever possible, minor problems are held for correction at PM time.
F-1 Failures are fixed as they occur. A failure noticed during PM results in a JCN action.

FYQ-47

C-1 Approximately 40% of failures found during PM, but are fixed during equipment down time.
C-2 Failures must be fixed before continuing P.M.I.

GPA-127

C-1 If found during PM, corrections are made, normal failures are called in by ops. troops.
D-1 Remaining failures usually found on scheduled maintenance.
D-2 Usually, unless discovered during operation rather than during P.M.I.
F-1 Whenever possible, however, they are mostly identified as a follow up JCN opened.

1.4 Is this system kept operational while failures in redundant units have occurred?

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	4	1			2	1				1	1			1						
B	2		1			2			1		1	1				1	1			
C	3	1								2	1				1	1				1
D	5				1			1			1					2				
E	2		1			2					2					2				
F			2			1	1			1						2	1			
G	2	1				1				1	1	1	1				1			1
TOTAL	18	3	4		3	7	1	1	1	5	7	2	1	1	1	8	3			2

1.5 Is this system maintained (unscheduled maintenance) while these failed units are being fixed?

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	3	3	1						1	1	1				1					
B	2		1			1		1		1	1	1						1	1	
C	2			1	1	2					1		1			1				1
D	5				1	1					1					2				
E	2		1			2					2									2
F			2			1				1						1	1	1		
G	2		1						2			2			1	1				1
TOTAL	16	3	6	1	2	7		1	3	3	6	3	1		2	5	1	2	1	4

1.6 Failures that occur are component failures?

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	4	2	1			1			1			2								
B	3					2				1	1			1				1	1	
C	1	3								2	2					2				
D	4	2				1							1			2				
E	2	1				1	1					2						1		1
F		2					3									1	2			
G		2		1		1	1				1	2				2				
TOTAL	14	12	1	1		6	5		1	3	4	6	1	1		7	2	2	1	1

1.4 Is this system kept operational while failures in redundant units have occurred?

FPS-27A

C-1 In most cases, spare units are available as supply point items.
C-2 Spare Tx channel and beams 1-8 are used.
D-1 Never-all elements are required for optimum performance.

FYQ-47

A-1 No redundant units.
C-1 System has no redundant units.
G-2 For training purposes.

GPA-127

C-1 With 3 identical units, at least one scope is operational 100% of the time.
C-2 No spare equipment assigned.
G-1 If any unit within the scope should fail, the entire scope would be inoperative.

1.5 Is this system maintained (unscheduled maintenance) while these failed units are being fixed?

FPS-27A

A-1 Supply point items are usually available.
C-1 Some spares have been on order for many months.
C-2 "Cannon ball" from beams 9 and 10.
D-1 Academic, since it usually takes only a few hours to fix an RDN unit if parts are available.
D-2 Only on units not in the primary line for Tx.

FYQ-47

A-1 System is operational; cards are repaired while equipment is operational, as a bench check off action.
C-1 No unless total system down (example main power supply failure.

GPA-127

D-1 All pieces of equipment always maintained.
F-1 Depends on nature of failure and maintenance action involved.
G-1 Entire scope would be down.

1.6 Failures that occur are component failures?

FPS-27A

C-1 With the exception of unit to modules, mixers, and RF and IF amplifiers

AN/GPA-124

A-1 Failures generally semiconductors or chips.
F-1 Serious programing errors at headquarters.

GPA-127

C-1 Drive gears are the major component failure.
D-1 Most failures consist of alignment nature, synchro, linearity, sweep length.
F-1 Most are gear and tube failures due to wear and deterioration.

1.7 Failures that occur are wiring/chassis failures?

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A			3		4					2				1	1					
B				1	2			1	1	1				1	1					2
C				3	1	1		1							2	1				1
D				1	5					1				1					1	1
E					3					2					2					2
F					2		1	1		1									2	1
G				1	2					2					3				1	1
TOTAL			3	6	19	1	1	3	1	9				3	9	1			4	8

1.8 Failures that occur are generally one component failures?

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	2	2	1	1	1	2			1		1			1						
B		3				3					1	1						2		
C		1	2	1		1				1		1	1			1				1
D	2	3	1				1					1				1		1		
E	1	1	1			1	1					2					1		1	
F	1				1		1	1	1								1	2		
G	2			1		1		1				1	1	1				1	1	
TOTAL	8	10	5	3	2	8	3	2	2	1	2	6	2	2		2	2	6	2	1

1.9 When more than one failure occurs, they occur in more than one subassembly?

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A			1	2	3				1	1			1		1					
B		1		1	1		1			2		1		1					1	1
C			1	2	1				1	1					2					2
D		1	2	1	2					1					1		1		1	
E		1			2				1	1					2			1		1
F				1	1	1	1	1										2		1
G	1			1	1					2					3				1	1
TOTAL	1	3	4	8	11	1	2	1	3	8		1	1	1	9		1	3	3	6

1.7 Failures that occur are wiring/chassis failures?

FPS-27A

- A-1 Matching plug-in cards with pins is troublesome.
- A-2 Pin contacts on circuit cards.
- C-1 More prone to occur where connections are made and broken many times.
- D-1 Wiring no problem. Rx chassis sometimes fails.

AN/GPA-124

- C-1 Have problem with loose pins.

FYQ-47

- G-1 Had wiring failures during installation, caused by metal filings on back plane.

1.8 Failures that occur are generally one component failures?

FPS-27A

- C-1 Secondary failures may occur.

AN/GRA-124

- C-1 Not many failures.
- F-1 Generally causes recording failures.

FYQ-47

- C-1 Some components cause other to fail.

GPA-127

Gear trains for sweep drive coil assembly.

1.9 When more than one failure occurs, they occur in more than one subassembly?

FPS-27A

- A-1 Have not had many multiple failures.
- C-1 Depends on nature and units involved.

FYQ-47

- C-1 Failures occur in one subassembly.

1.10 Environment (cold, heat, rain) contribute to the maintenance problem?

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A		1	2		4				1	1			1		1					
B		2	1			1				2		1			1					2
C			2	1	1	1		1							2	1				1
D		3		1	1			1					1						1	1
E				1	2					2					2					2
F				2			1	1		1									1	2
G			3					1	1					2	1				1	1
TOTAL		6	8	5	8	2	1	4	2	6		1	2	2	7	1			3	9

1.11 While performing maintenance, physical proximity (upstairs, downstairs, base) contributes to the unscheduled maintenance down times?

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	1	1		1	4					2					2					
B				1	2					3					2					2
C				1	3					2					2		1	1		
D				1	5					1				1				1	1	
E		1	1		1					2					2		1	1		
F			1	1						3								1		2
G			1		2					2			1		2			1		1
TOTAL	1	2	3	5	17					15			1	1	10		2	5	1	5

1.12 Do all technical manuals for equipments have similar formats such that, when required, procedures can be located without unnecessary delay?

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	2	2		2	1	1		1			2									
B			2		1	2	1						1	1			1		1	
C		3		1		1						1		1		2				
D	1	3	1		1	1									1	2				
E	1			2						2	2						2			
F		1			1		1	1	1							1	1		1	
G	1				1	1	1				1	2					1	1		
TOTAL	5	9	3	5	5	6	3	2	1	2	5	3	1	2	1	5	5	1	2	

1.10 Environment (cold, heat, rain) contribute to the maintenance problem?

FPS-27A

A-1 Temperature has a noted effect on equipment alignment.
A-2 Temperature - equipment doors must be left open most of the time. Suggest removing them.
A-3 Excessive heat in summer causes Unit to overheat. Some malfunctions have occurred.
C-1 Rx heat sensitive, adjustments/alingments vary.
C-2 Adverse conditions may cause early failure of exposed motors, fans, etc.
D-1 Rx degraded in summer - tower not A/C'ed; Tx degraded in winter - tower heating problem.
D-2 Some summer overheat problems in Rx.
G-1 Heat in Unit 6 causes alignment changes.

AN/GPA-124

C-1 Temperature
C-2 Dust in vacuum equipment produces failures.
D-1 Heat contributes to maintenance.
F-1 Temperature is 75 deg or above when fault occurs.
G-1 Equipment is heat sensitive.
G-2 Heat affects equipment operation.

FYQ-47

B-1 90 deg F or higher causes internal problems
C-1 Above 80 deg
G-1 High Humidity.

GPA-127

C-1 Age is prime factor.
D-1 Sometimes get cold enough in working area to cause technician discomfort.

1.11 While performing maintenance, physical proximity (upstairs, downstairs, base) contributes to the unscheduled maintenance down times?

FPS-27A

C-1 Time required to get to failure location.

FYQ-47

G-1 Not on base.

GPA-127

A-1 Maintenance time is sometimes extended, because of two units in operations area, 50 yds apart.
A-2 Two of three scopes are located in operations area, away from tool boards and bench stock.
D-1 On scopes in operations tool and test equipment have to be carried to that area.
F-1 Only to duration of the fix action.

1.12 Do all technical manuals for equipments have similar formats such that, when required, procedures can be located without unnecessary delay?

FPS-27A

C-1 Format varies among equipments - systems not easily combined - interwiring diagrams nonexistant.
C-2 May depend on technician's experience and familiarity.
D-1 The -9 T.O. is readily available.
F-1 T.O.'s are quite different from system to system.
G-1 T.O.'s 2-8, 3-8 and 4-8 should be on the same units.

AN/GPA-124

A-1 Parts of T.O. are hard to read, different adjustments seen to run together.

FYQ-47

D-1 Manuals are not detailed, need trouble shooting procedures.

1.13 Are tech manuals of sufficient clarity to facilitate maintenance?
a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, e. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	3	2	1	1			2				1	1								
B		1	2			1	1	1				1	1				1	1		
C		4				1		1				1		1		2				
D	3	2			1	1						1				2				
E	1			2		1	1					2				1	1			
F			1		1		1		1	1						1	1		1	
G		1	1	1			2				2	1					2			
TOTAL	7	10	5	4	2	4	7	2	1	1	3	7	1	1		6	5	1	1	

1.14 Do administrative activities (leave, K.P., etc) influence maintenance times?
a. 100 to 90%. b. 90 to 70%. c. 70 to 30%. d. 30 to 10%. e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A				2	5					2					2					
B			1	1	1					3					2					2
C			1	1	1		1			2					2					2
D					6					1				1						2
E					3			1		1					2					2
F			1	1					2	1								1	1	1
G				2	1				1	1				1	2				2	
TOTAL			3	7	17		1	1	3	11				2	10			1	3	9

1.15 Do any base safety regulations hinder maintenance?
a. 100 to 90%. b. 90 to 70%. c. 70 to 30%. d. 30 to 10%. e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A				1	6					2					2					
B					3					3				1	1					2
C				1	3	1				1					2					2
D					6					1				1						2
E					3				1	1					2					2
F					2					3										3
G				2	1					2					3					2
TOTAL				4	24	1			1	13				2	10					13

1.13 Are tech manuals of sufficient clarity to facilitate maintenance?

FPS-27A

C-1 If additional help is given by experienced maintenance technician.
C-2 T.O.s could be better organized.
C-3 May depend on technicians experience.
D-1 The -9 T.O. has clear instructions and is easy to follow.
E-1 For several procedures, the T.O. must be read 2 or 3 times before the steps are clear.
F-1 T.O.s have numerous errors and are still in revision. No AF T.O. form 22s being accepted from field.
G-1 Logic diagrams of Unit 6 are a big circle.

AN/GPA-124

B-1 A lot of time is wasted tracing signal in T.O.
C-1 Must trace back and forth.
F-1 Manual terrible - does not show all locations of components or not all components.

1.14 Do administrative activities (leave, K.P., etc) influence maintenance times?

FPS-27A

A-1 Squadran detail, leave and passes reduce maintenance time by 60 days/man/year.
C-1 Mess check, bay orderly, base detail, etc.
F-1 Personnel manning is sufficient.

FYQ-47

G-1 Affects training time.

GPA-124

F-1 We are staffed to complete our work as scheduled.
G-1 Sometimes have to bring man in on weekends to trouble shoot complex problems.

1.15 Do any base safety regulations hinder maintenance?

FPS-27A

C-1 In some cases, safety is being overstressed (AF regs.)
E-1 There are no safety rules that would not be performed anyway as a logical precaution.

FYQ-47

C-1 10 to 30% if all safety regulations were followed.

1.16 Do any equipment designed safety procedures hinder maintenance?

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A				2	5					2					2					
B					3					3				1	1					2
C				2	2	1				1					2					2
D				2	4					1			1							2
E				1	2					2					2					2
F					2				3											3
G				1	2					2				1	2				1	1
TOTAL				8	20	1			3	11			1	2	9				1	12

1.17 Do all phases of maintenance have adequate light for visibility?

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	1	2	1	2	1	1	1				1		1							
B	1	1	1			3					1			1		2				
C		3	1			2						1	1			2				
D	3	3				1								1		2				
E	2		1			2					2							2		
F			1		1	1	2									1	1		1	
G	1		1	1		2					1	2							2	
TOTAL	8	9	6	3	2	12	3				5	3	2	2		7	1	2	3	

1.18 Does equipment have enough working area (distance from walls) such that there is adequate working space when performing maintenance?

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	4		1		2	1		1			1		1							
B	1	1		1		1	2				1	1					2			
C		4							1		2					2				
D	4	2				1								1		1	1			
E	2	1				1	1				2							1	1	
F		2				1	1		1							1	1			1
G	1	1		1			2				1	1	1				1	1		
TOTAL	12	11	1	2	2	5	6	1	2		7	2	2	1		4	5	2	1	1

1.16 Do any equipment designed safety procedures hinder maintenance?

FPS-27A

- C-1 Interlocks bypass switches should be located on the outside of an equipment box. The interlock system, requiring keys, is impractical.
- C-2 Time delays after power turned back on, interlocks cheated, power applied when cabinet access is required in some units.
- D-1 Key interlock on Tx sometimes causes problems working in shielded room with power on.

1.17 Do all phases of maintenance have adquate light for visibility?

FPS-27A

- A-1 Work in the rear of Unit 6 requires a light.
- A-2 Poor lighting behind Unit 6.
- C-1 Extra lighting is needed most times.
- C-2 Portable lights may be required.
- D-1 Some components are located where a flashlight or dropcord light must be used.
- G-1 Some cabinets should have lights because tower floor lighting is inadequate.

FYQ-47

- C-1 A light is needed within the FYQ-47
- C-2 RCU has no space for light and tech.

GPA-127

- E-1 Hampered by having to keep ops room dimmly lit.
- E-2 Operations is always dim, the P/S drawer cannot be worked on without a flashlite.
- F-1 Where fixed lighting is inadequate, drop cord lights are used
- F-2 Operations room must be kept dark.

1.18 Does equipment have enough working area (distance from walls) such that there is adequate working space when performing maintenance?

FPS-27A

- A-1 Due to design and physical proximity, the entire IP unit has to be removed when rewiring or soldering resistors, caps or diodes.
- D-1 Space is needed around the water system.
- E-1 Unit 5 is too close to column.
- G-1 At console is too close to wall when the 2A2 is open.

AN/GPA-124

- A-1 Equipment installed too close to wall.
- C-1 Back of equipment is hard to get to.
- G-1 Back phase of main unit too close to wall.

FYQ-47

- A-1 RCU is difficult to work on internal components

GPA-127

- D-1 Location is big factor, has only limited spaces.
- E-1 This is a major problem due to proximity of other equipment.
- E-2 The ehight finder scope hinders one space.
- G-1 Scopes are placed too close together.

1.19 When performing maintenance, does one man read instrunctions to other man who is in equipment performing necessary unscheduled maintenance?

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A		3	2	1	1	1	1					2								
B	1	1		1		1	2					1	1					1	1	
C		1	3				3				1	1							1	1
D	5	1						1					1			1	1			
E		1	1		1			1	1			1	1				1		1	
F				2		1	1		1							1		2		
G			1	2		1	1					3					1	1		
TOTAL	6	7	7	6	2	4	8	2	2		1	8	3			2	3	4	3	1

1.20 What personnel improvements would you suggest to minimize system downtime?

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	4		1	2		2				1	2				1					
B	2			1		3			2		2	1		1						1
C	3	1	2	2	4	2			1		2		1	1	1	2				1
D	6				2				1		1			1		2			1	1
E	2			2	2	2				1	2			1	2	2			1	
F	2		1	2	1	2			2	1						2		1	2	
G	3		1	3		2			2		2					1				
TOTAL	22	1	5	12	9	13			8	3	11	1	1	4	4	9		1	4	3

1.20a What personnel improvements would you suggest to minimize system downtime?

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A			4	4				1					1							
B			2	3	1				1				1	1					2	
C			1	2	3										1			1	2	1
D				1	4								1	1						
E									1					2				2		
F	1	1	1	2	1		1	1	2	1								2		1
G			2	2							1				1				2	
TOTAL	1	1	10	14	9		1	2	4	1	1		3	4	2			5	6	2

1.19 When performing maintenance, does one man read instructions to other man who is in equipment performing necessary unscheduled maintenance?

FPS-27A

- A-1 While aligning North mark, one man adjusts synchro while another checks the alignment of the North mark with zero degrees.
- C-1 Depends on availability of maintenance personnel.
- C-1 Second man there for safety reasons.
- F-1 After reading through procedure, the man performing will reread as he goes along.

GPA-127

- C-1 During alignments
- C-2 Normally both technicians use T.O. together.
- F-1 Mostly when fix action is in.

1.20 What personnel improvements would you suggest to minimize system downtime?

FPS-27A

- A-1 Static tester should be available so that a channel does not have to be down to troubleshoot.
- A-2 Entire gear train assembly should be on supply point.
- D-1 Change of weekly phase inspection to monthly.
- D-2 More information on circuit theory and design.
- E-1 More on-equipment training.

FYQ-47

- A-1 Constant training necessary due to system reliability.
- D-1 More troubleshooting during maintenance.

1.20a What personnel improvements would you suggest to minimize system downtime?

GPA-127

- E-1 Repair manual separate from basic T.O.
- F-1 Schematics and operations should be together.
- G-1 Less time for supply to receive parts.

1.21 Generally, how much on-duty time involves writing failure reports?

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A			1	4	2				2					1	1					
B			1	1	1			1		2		1		1				1	1	
C			1	3					1	1				1	1					2
D				5	1					1					1				1	1
E				1	2					2					2				1	1
F				2				2	1										3	
G				3						2				1	2				1	1
TOTAL			3	19	6			3	4	8		1		4	7			1	7	5

1.22 What system improvements would you suggest to minimize system downtime?

a. improved packaging, b. more built-in test, c. more test points, d. marking test points with volts, amps, etc, e. greater use of plug-in devices.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	1	3	3	1	1		1	1		1										
B	1	1	1	1	1	1									1		2	1	1	1
C	1		3		3				1									1	1	
D	4			1	4		1					1	1					1		
E		2	1	2	1		1	1	1	1		1		1			1	1	1	
F	2	2	2	1	1	1	2	1								1		1	1	1
G	1	1	1	1			2	1										1		
TOTAL	10	9	11	7	11	2	7	4	2	2		2	1	1	1	1	3	6	4	2

1.22a What system improvements would you suggest to minimize system downtime?

a. more quick-release fasteners, b. quick-release electrical connections, c. more fault indicators (lights, meters, etc), d. improved logistic support, e. other

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A			3	2		2														
B	1			2		2	1		1			2						2		
C	2	2	3	2		3		1						2			1		2	
D	2	3		2							1		1					1		
E	1		1			1		1						1		1	2			
F	2	2	1	2	1	1	1	1											2	
G	2	1		1				1						1			2	1	2	
TOTAL	10	8	8	11	1	9	2	4	1		1	2	1	4		1	5	4	6	

1.21 Generally, how much on-duty time involves writing failure reports?

1.22 What system improvements would you suggest to minimize system downtime?

FPS-27A

- A-1 Routine maintenance should not require access to tops of cabinets.
- D-1 Change phase inspection to a monthly requirement.
- D-2 Better cooling on Rx cabinet.
- G-1 Ability to work on individual channels without terminating front end.

FYQ-47

- A-1 More spare cards for repair actions.
- C-1 Dual channel operation.

GPA-127

- D-1 Satisfactory as is.
- F-1 More rapid time change conditions as these units are very old.

1.22a What system improvements would you suggest to minimize system downtime?

1.23 What kind of failures are not reported on 349 forms?
a. secondary, b. test equipment, c. other

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A		6	1			1					1		1							
B		3					2			1	1	1				1	1			
C		4					1					2					2			
D		5										1					2			
E		3					1	1				1					1			
F	1	2	2			1	2										3			
G	1						1					2	1				2			
TOTAL	2	23	3			2	7	1		1	2	7	2			1	11			

1.24 Are secondary failures reported as part of original failures?
a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	1	2		4					1	1				1	1					
B	1		1			1				1					2		1	1		
C		2	2			1				1	2					1		1		
D		3		2	1	1									1	1				1
E	1		2					1		1			1		1		2			
F	1			1					1	1						1	1	1		
G	1		1		1				1	1			1	1	1			1	1	
TOTAL	5	7	6	7	2	3		1	3	6	2		2	2	6	3	4	4	1	1

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A																				
B																				
C																				
D																				
E																				
F																				
G																				
TOTAL																				

1.23 What kind of failures are not reported on 349 forms?

FPS-27A

G-1 Minor front panel adjustments.

FYQ-47

A-1 Failure not related to Q-47

G-1 Light bulbs.

GPA-127

Failures with less than 3 minutes duration.

1.24 Are secondary failures reported as part of original failures?

FPS-27A

B-1 No knowledge of what a secondary failure is.

D-1 If the repairs are in the same general area or section as the original failure they are documented on the 349 using different work unit codes.

D-2 When the cause of the failure is in two or more areas.

FYQ-47

C-1 If caused by original failure.

GPA-127

C-1 Secondary failures are usually caused by technicians while troubleshooting primary failure.

F-1 Reporting system states that original problem will be resolved, than initiate work on secondary unless secondary problem more significant. Most maintenance personnel will fix original & secondary probiem at same time, with all time taken against original problem.

1.25 When do most failures seem to occur?

a. morning, b. afternoon, c. evening

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A		1	2																	
B		1				1	1	1					2							
C						1	1				1	1								
D		2	3				1	1									1			
E		2	2				1					1						2		
F		1				1	1	2								1	1	1		
G	1	1					2						2			1		1		
TOTAL	1	8	7			3	7	4			1	2	4			2	2	4		

1.26 What percentage of "can-not-duplicate" failures occur for line replaceable units?

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A		2	2	1	2				1	1				1	1					
B			2		1			1	1	1			2					1	1	
C					4					1					2				1	1
D				5						1										2
E				1	2				1	1				1	1				2	
F		1		1					2										1	2
G	1			1	1				1	1				2	1				1	1
TOTAL	1	3	4	9	10			1	6	6			2	4	5			1	6	6

1.27 How often do failures occur when conducting preventive/scheduled maintenance?

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A			2	2	3					2				1						
B			1	2						3			2	1					1	1
C		1		3						2			1		1				1	1
D				3	2					1							1			1
E				2	1				1	1					2					2
F				1	1				1	2									2	1
G		1		2						2					3				1	1
TOTAL		2	3	15	7				2	13			3	2	6		1		5	7

1.25 When do most failures seem to occur?

GPA-127

- B-1 No particular time.
- B-2 No particular time.
- C-1 Failures are scattered.
- C-2 Failures have no time table.
- D-1 Can happen anytime, equipment is operational 24 hours each day.
- G-1 When equipment has had heaviest use for the day at site level.

1.28 How often do system intermittent failures occur?

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A			2	4	1				1	1				1	1					
B				1	2				1	2		1	1						2	
C			1	3						2					2				1	1
D		1		1	3					1									2	
E			1		2					2					2					2
F				2			1	1		1									2	1
G				2	1				2					1	2			2		
TOTAL		1	4	13	9		1	1	4	9		1	1	2	7			2	7	4

1.29 Are intermittent failures reported as legitimate failures?

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A		2		1	4	1				1	1				1					
B	1	1			1				1	2			1		1				1	1
C	1	1	1	1		1		1			1			1		2				
D			1	2	2	1											1			
E				2	1	1				1			1		1				2	
F			1	1					1	2							2			1
G	2		1						2		1			1	1			2		
TOTAL	4	4	4	7	8	4		1	4	6	3		2	2	4	2	3	2	3	2

1.30 When a failure occurs during preventive/scheduled maintenance are the repair and scheduled tasks reported as a combined effort?

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	2		1	2	2	2					2									
B		2	1			1	1			1		1	1						1	1
C		1		3		1				1					2					2
D	1	1		1	2	1										2				
E	1		1	1				1		1				1	1					2
F			1	1			1			1									1	2
G	1	1	1							1		1		1	1		1	1		
TOTAL	5	5	5	8	4	5	2	1		5	2	2	1	2	4	2	1	1	2	7

1.28 How often do system intermittent failures occur?

1.29 Are intermittent failures reported as legitimate failures?

FPS-27A

- C-1 Those that cause substantial downtime or excessive maintenance.
- D-1 Depending on the time of the problem and if parts were in repairing.
- D-2 Only if the intermittent problem becomes frequent and hinders equipment operation.
- F-1 Only if it causes system outage or recovery is excessive.

FYQ-47

- C-1 Failure must be corrected before PMI can continue, downtime for PMI is different from "red" time.

GPA-127

- C-1 These failures are coded as C.N.D.s
- D-1 If downtime required is 15 minutes or more.

1.30 When a failure occurs during preventive/scheduled maintenance are the repair and scheduled tasks reported as a combined effort?

FPS-27A

- C-1 If the two are related.
- C-2 New JCN
- E-1 A trailer ESR is usually opened against the failure.

GPA-127

- G-1 P.M. time is closed and a malfunction ticket opened.
- D-1 The 349 initiated for the repair uses the JCN as the P.M.I.
- F-1 When a failure occurs during P.M.I., P.M.I. is terminated and JCN is opened, when failure is repaired, the P.M. is completed. Exception - Failure can be cleared by external adjustment

1.31 Do you feel most failures are caused by thermal or electrical stress?

a. thermal b. electrical, c. no opinion

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	3	3	1				2					2								
B	3							3					2				2			
C	2	1						1				1	1			1		1		
D	5	1				1										1	1			
E		2	1				1	1					2				2			
F	1	1				1		1								1		1		
G		1	2			3					1	1	1				1	1		
TOTAL	11	9	4			5	3	6			1	4	6			3	6	3		

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A																				
B																				
C																				
D																				
E																				
F																				
G																				
TOTAL																				

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A																				
B																				
C																				
D																				
E																				
F																				
G																				
TOTAL																				

1.31 Do you feel most failures are caused by thermal or electrical stress?

GPA-127

F-1 Mechanical – Gear train is biggest problem with this equipment.

2. PHYSICAL DESIGN FEATURES

2.1 ACCESS (EXTERNAL)

External access is adequate for: a) visual and manipulative tasks, b) visual but not manipulative tasks, c) meet one or more of the above three criteria.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	4	1		1		2						2								
B	1	2				1	1				1			1			2			
C	4										2					2				
D	6													1		2				
E	2	1									2						2			
F	1	1				2	1									2	1			
G	3					2					3					1	1			
TOTAL	21	5		1		7	2				8	2		2		7	6			

2.2 LATCHES AND FASTENERS (EXTERNAL)

External latches and/or fasteners: a) are captive, need no special tools, and require only a fraction of a turn for release. b) meet two of the above three criteria. c) meet one or more of the above 3 criteria.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	3	3					1	1			2									
B	2	1					1	1			1	1				1		1		
C	1	3									2					1		1		
D	5	1									1					2				
E	2	1									2					1		1		
F		1	1			2		1								1	2			
G	1	2					2				2	1				1	1			
TOTAL	14	12	1			2	4	3			10	2				7	3	3		

2.3 LATCHES AND FASTENERS (INTERNAL)

Internal latches and/or fasteners: a) are captive, need no special tools, and require only a fraction of a turn for release; b) meet two of the above three criteria; c) meet one or more of the above three criteria.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	2	3	1				1	1			2									
B		3					1	1			1	1				1		1		
C	1	3									1	1				1	1			
D	3	3									1					2				
E		1	2								2					1		1		
F		1	1				2	1								1	1	1		
G		3				1	1				2	1				1	1			
TOTAL	6	17	4			1	5	3			9	3				7	3	3		

2.1 ACCESS (EXTERNAL)

FPS-27A

C-1 Difficulty exists in Tx area – cramped – exposure to H.V.

FYQ-47

A-1 RCU is very hard to work on, the drawer is underneath a shelf and is very easy to be injured.

GPA-127

E-1 Problem mainly proximity of other equipment.

E-2 The 1x and 36x synchros are in difficult position to align or replace.

2.2 LATCHES AND FASTENERS (EXTERNAL)

FPS-27A

C-1 Often difficult to turn

GPA-124

A-1 Cannot be forced without use of screwdriver, also too many fasteners

E-1 Filters are held by screws and should be replaced with quick release attachments.

2.3 LATCHES AND FASTENERS (INTERNAL)

FPS-27A

C-1 Often difficult to turn.

GPA-127

C-1 Require more than a fraction of a turn.

2.4 ACCESS (INTERNAL)

Internal access is adequate for: a) both visual and manipulative tasks; b) visual but not manipulative tasks; c) manipulative but not visual tasks; d) neither visual or manipulative tasks.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	4			2		1		1			1	1								
B	2			1		1			1		1	1								
C	3	1									1			1						
D	6													1						
E	2	1									2									
F	2					1	1	1												
G	2			1		2					2			1						
TOTAL	21	2		4		5	1	2	1		7	2		3						

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A																				
B																				
C																				
D																				
E																				
F																				
G																				
TOTAL																				

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A																				
B																				
C																				
D																				
E																				
F																				
G																				
TOTAL																				

2.4 ACCESS (INTERNAL)

FYQ-47

C-1 RCU exhaust fans almost impossible to get to also memory fans in Q-47.

G-1 Certain units (example A7 board) are very difficult to get to.

GPA-127

B-1 Some manipulations difficult (synchros)

C-1 Specifically, yoke adjustments are too close to the slip rings.

E-1 Tube replacement, gear train adj., synchro adj. present difficulties.

F-1 Routing of some wires, and placement of gears and components makes it almost impossible to check unless you are very ambidextrous.

3. MAINTENANCE CONCEPT

3.1 System repair is accomplished by replacing faulty assemblies with an identical operational spare

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	1	2	1		3					1				1	1					
B	2				1	2				1	1	1							1	1
C		1	1	2						2	1				1					2
D	1	2		2	1		1								1	1				1
E			1		2					2		1			1					2
F			2			2		1												3
G		2			1	1				1	1			1	1		1			1
TOTAL	4	7	5	4	8	5	1	1		7	3	2		2	5	1	1		1	10

3.2 System is accomplished by repairing faulty subassemblies (boards) through replacement of identical operational spare.

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	1	1	2	2	1	1				1	2									
B	1		1	1		2				1	1		1				1			1
C	1		3				1			1	2									2
D	1	4	1								1					1				1
E			2		1	1	1				1				1					2
F			2			2	1													3
G	1	1	1			1				1	3									2
TOTAL	5	6	12	3	2	7	3			4	10		1		1	1	1			11

3.3 System repair is accomplished at the site

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	4	3				2					2									
B	2		1			2				1	1		1			2				
C	2	2				2					2					2				
D	5	1					1				1					2				
E	3					1					2					2				
F	1	1				2	1									3				
G	3					2					2	1				2				
TOTAL	20	7	1			11	2			1	10	1	1			13				

3.1 System repair is accomplished by replacing faulty assemblies with an identical operational spare

FPS-27A

- A-1 There should be an entire gear train assembly on supply point.
- C-1 This type repair is normally only used on Tx.

GPA-124

- C-1 No spare assemblies.

FYQ-47

- C-1 Almost 90% of system is boards.

GPA-127

- C-1 No spare available.
- D-1 No spares on hand.
- F-1 Most failures have to be troubleshot to a specific component for repair and/or replacement.
- F-2 The unit is small and has no operational spares at this level.

3.2 System repair is accomplished by repairing faulty subassemblies (boards) through replacement of identical operational spare

FPS-27A

- A-1 In the IP unit, resistor boards must be trouble shot and repaired in order to complete the scheduled/preventive or unscheduled maintenance.
- C-1 On Rx more than Tx systems.
- C-2 Depends on unit involved.

GPA-124

- C-1 Most problems are loose pins, but repair is by card replacement.
- G-1 Have contract maintenance on boards, sent to depot.

GPA-127

- F-1 No spares
- G-1 Boards cannot be replaced.

3.3 System repair is accomplished at the site

FPS-27A

- D-1 All assemblies not listed in the -6 manual are repaired on site.
- F-1 Most boards are not authorized for repair at the site level.

3.4 System repair is accomplished at a remote shop

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A				1	6	1				1					2					
B				1	2	2				1				1	1					2
C					4					2					2					2
D				1	5					1					1					2
E					3	1				1					2					2
F					2					3										3
G					3					2					3		1			1
TOTAL				3	25	4				11				1	11		1			12

3.5 System repair is accomplished at a depot (Military or otherwise)

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A				1	6					2					2					
B				1	2	1				2					2					2
C					4					3					2					2
D					6					1					1					2
E					2					2					2					2
F					2				1	2										3
G					3					2					3					2
TOTAL				2	25	1			1	14					12					13

3.6 Assembly repair is accomplished at the site

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, e. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	5	1		1		2					2									
B	1		2			2				1		1		1		1				1
C	2	2				1				1	2					2				
D	4	1	1			1					1					2				
E	1	1	1					1		1	2					2				
F	2					1	2									3				
G	2	1				1				1	2	1				2				
TOTAL	17	6	4	1		8	2	1		4	9	2		1		12				1

3.4 System repair is accomplished at a remote shop

FPS-27A

C-1 Electromechanical repairs are sometimes made at a remote shop.

GPA-124

C-1 Cards sent to depot for repair.

GPA-127

C-1 No unless DIFM item fails – motor, etc.

3.5 System repair is accomplished at a depot (Military or otherwise)

FPS-27A

C-1 Rx modules 100%

GPA-127

C-1 For DIFM items only.

D-1 Only for complete overhauls.

3.6 Assembly repair is accomplished at the site

FPS-27A

C-1 Large items are not repaired at the shop.

D-1 Goal is 100%, if not listed in -6 T.O.

GPA-124

Loose pins are re-installed.

GPA-127

C-1 This is for gear trains etc, when rebuilding.

3.7 Assembly repair is accomplished at a remote shop

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A				1	6					2					2					
B		1			2	1				2				1	1					2
C					4					2					2					2
D					6					1					1					2
E				1	2	1				1					2					2
F					2					3										3
G	1				2	1				1					3		1			1
TOTAL	1	1		2	24	3				12				1	11		1			12

3.8 Assembly repair is accomplished at a depot (Military or otherwise)

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A				1	6					2					2					
B		1			2	1				2					2					2
C					3					2					2					2
D				1	5					1					1					2
E			1	1	1			1		1					2					2
F					2				1	2										3
G	1				2					2					3					2
TOTAL	1	1	1	3	21	1		1	1	12					12					13

3.9 Subassembly (board) repair is accomplished at the site

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	6	1				1	1				2									
B		1	1		1					3	1		1			2				
C	3	1								2	2					2				
D	4	1			1	1					1					2				
E	3					1				1	2					2				
F	2					2	1									3				
G	3									2	3					2				
TOTAL	21	4	1		2	5	2			8	11		1			13				

3.7 Assembly repair is accomplished at a remote shop

3.8 Assembly repair is accomplished at a depot (Military or otherwise)

3.9 Subassembly (board) repair is accomplished at the site

GPA-124

G-1 Boards are sent to depot for repair.

3.10 Subassembly (board) repair is accomplished at a remote shop

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A			1		6					2					2					
B		1			2	1				2				1	1					2
C					4	1				1					2					2
D				1	5					1					1					2
E					3					2					2					2
F					2					3										3
G					3	1				1					3		1			1
TOTAL		1	1	1	25	3				12				1	11		1			12

3.11 Subassembly (board) repair is accomplished at a depot (Military or otherwise)

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A				1	6				1	1					2					
B	1	1			1	3									2					2
C					4	2									2					2
D	1			1	4					1					1					2
E					3	1			1						2					2
F					2				1	2										3
G					3	2									3					2
TOTAL	2	1		2	23	8			3	4					12					13

3.12 Subassembly (board) repair is accomplished by replacing faulty subassemblies.

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	2	2		1	2					2					2					
B	1	1	1			1		1		1		1	1							2
C	1		1	2		1				1					2					2
D	3		1	2		1									1	1				1
E	1				2	2					1				1					2
F					2		1			2										3
G	2	1				1					2				1					2
TOTAL	10	4	3	5	6	6	1	1		6	3	1	1		7	1				12

3.10 Subassembly (board) repair is accomplished at a remote shop

3.11 Subassembly (board) repair is accomplished at a depot (Military or otherwise)

FPS-27A

C-1 Some – RF amps and mixers from Rx

3.12 Subassembly (board) repair is accomplished by replacing faulty subassemblies.

FPS-27A

A-1 Subassembly must be repaired on site in order to complete maintenance action.

C-1 Some Rx boards – log amp, limiter amps

E-1 Rx IF Boards

FYQ-47

D-1 Cards are checked in card checker.

3.13 Subassembly (board) repair is accomplished by replacing faulty discrete components

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	4	3				2					2									
B	1		1		1	2				1		1		1			2			
C	2		1	1						2	2					1				1
D	2	2		1	1	1					1					2				
E	1	1			1	1				1	2								2	
F	2					1			2							3				
G	2	1								2	2				1	2				
TOTAL	14	7	2	2	3	7			2	6	9	1		1	1	8	2		2	1

3.14 Site personnel repair the system

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, e. 30 to 10%, d. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	7					2					2									
B	2	1				2				1	1	1				2				
C	3	1				2					2					2				
D	6					1					1					2				
E	3					2					2					2				
F	2					2	1									3				
G	3					2					3					2				
TOTAL	26	2				13	1			1	11	1				13				

3.15 Site personnel repair the assembly

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	6	1				2					2									
B	1	1	1			2				1	1	1				2				
C	3	1				1				1	2					2				
D	6					1					1					2				
E	3					2					2					2				
F	2					2	1									3				
G	3									2	3					2				
TOTAL	24	3	1			10	1			4	11	1				13				

3.13 Subassembly (board) repair is accomplished by replacing faulty discrete components

FPS-27A

E-1 Tx section

3.14 Site personnel repair the system

GPA-124

C-1 Loose pins

3.15 Site personnel repair the assembly

GPA-124

C-1 Not able to repair boards

3.16 Troubleshooting the system requires supportive test equipment

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	4	1		1	1	1	1					2								
B	1	2				3						1		1		1	1			
C	2	2				2					1	1				1	1			
D	4	1	1			1								1		2				
E		1	1		1	1			1		1	1					1	1		
F	1					1	2									2		1		
G	1	1	1			2						3					2			
TOTAL	13	8	3	1	2	11	3		1		2	8		2		6	5	2		

3.17 Isolating to faulty assembly requires supportive test equipment

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	5			1	1	1			1			2								
B	1	2				3						2				1			1	
C	2	2				2					1	1				1	1			
D	4		1			1								1		1	1			
E	1	1			1	2					1			1				1	1	
F	1		1			3										1		1		1
G	1		1		1	1	1				1	2					2			
TOTAL	15	5	3	1	3	13	1		1		3	7		2		4	4	2	2	1

3.18 Spare assemblies are available at the site

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	1	2	1	1	2					2					1					
B	1		2			1			1	1			1	1	1					2
C		1		1	2					2		1			1					2
D	1	4			1	1					1					1				1
E				2	1	1				1		1	1							2
F		1			1		2			1										3
G		1		1	1	1				1	2	1								2
TOTAL	3	9	3	5	8	4	2		1	8	3	3	2	1	3	1				12

3.16 Troubleshooting the system requires supportive test equipment

FPS-27A

A-1 Scope, power meters and RF voltmeter

GPA-127

E-1 PSM-6 or scopes.

3.17 Isolating to faulty assembly requires supportive test equipment

GPA-127

D-1 Sometimes the scope presentation indicates problem.

3.18 Spare assemblies are available at the site

FYQ-47

E-1 Assemblies not replaced for most part.

GPA-127

C-1 Other than cannibilization there are no assembly spares.

C-2 No spares available.

3.19 Spare subassemblies (boards) are available at the site

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	1	3	1	1	1	1	1				1	1								
B			2	1		3					1	1								2
C		3		1		2					2									2
D	1	4	1			1					1					1				1
E	1		1	1		2					2									2
F		1	1			2	1													3
G		2	1			2					3									2
TOTAL	3	13	7	4	1	13	2				10	2				1				12

3.20 Spare assemblies are available at the Base Maintenance Shop

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A										2					2					
B										2				1	1					2
C										2										2
D										1										1
E										2	1	1								2
F										3										2
G										2							1			1
TOTAL										14	1	1		1	3		1			10

3.21 Spare subassemblies (boards) are available at the Base Maintenance Shop

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A						1				1					2					
B						1				2	1			1						2
C						1				1										2
D										1										1
E						1				1	2									2
F										3										2
G						1				1										2
TOTAL						5				10	3			1	2					11

3.19 Spare subassemblies (boards) are available at the site

FPS-27A

B-1 The most needed are on supply point but are very seldom available. (RF amps & IF Amp det)

C-1 Rx -70 to 90, Tx -10 to 30, Elec-Mech -0 to 10.

GPA-124

C-1 All boards have spares.

GPA-127

C-1 Other than cannibilization there are no spares available.

3.20 Spare assemblies are available at the Base Maintenance Shop

3.21 Spare subassemblies (boards) are available at the Base Maintenance Shop

FYQ-47

B-1 Have own stock.

3.22 Spare assemblies may be obtained from shop supply without a direct exchange of an identical faulty unit

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A		1	1	1	4					2				1	1					
B				1	2					3					2					2
C	1	1			1					2	1				1					2
D	4	1								1						1				1
E	1				1	1				1	2								1	1
F					2					3										3
G	1				2					2	2				1					2
TOTAL	7	3	1	2	12	1				14	5			1	5	1			1	11

3.23 Spare subassemblies may be obtained from shop supply without a direct exchange of an identical faulty unit

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A		1	1		5	1			1		1	1								
B				1	2	1				2			1		1					2
C	3	1				1				1	1				1					2
D	5	1								1						1				1
E	1				1	2					2								1	1
F					2				1	2										3
G	1			1	1	2					2				1					2
TOTAL	10	3	1	2	11	7			2	6	6	1	1		3	1			1	11

3.24 Assemblies are depot repairable units

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	1	1		2	3					2			1		1					
B	1	1		1		1			1	1		1		1			1			1
C			2	1	1	1	1								2				1	1
D	1	1		1	3					1					1					2
E			1	1	1					2				1	1				1	1
F				1	1				1	2						1				1
G			1		2	2									3	1				1
TOTAL	3	3	4	7	11	4	1		2	8		1	1	2	8	2	1		2	7

3.22 Spare assemblies may be obtained from shop supply without a direct exchange of an identical faulty unit.

FPS-27A

C-1 Takes about 10 days to return item.
C-2 Spare Assembly's normal must be ordered.
D-1 Material Control is notified when assemblies are exchanged to take proper action on the defective item.

FYQ-47

C-1 No Shop Supply of assemblies.
C-2 IF on supply point.

3.23 Spare subassemblies may be obtained from shop supply without a direct exchange of an identical faulty unit

FPS-27A

C-1 Takes about 10 days to return item.
D-1 Through use of supply point items.
D-2 Material Control is notified when boards are exchanged to take proper action on the defective items.

GPA-124

E-1 Non-operative boards replaced with new ones, also boards used as troubleshooting aid.

FYQ-47

C-1 If on supply point.

3.24 Assemblies are depot repairable units

FPS-27A

A-1 Some assemblies are XD2 items and the site is not authorized to fix them.
C-1 Rx -90 to 100? Tx -10 to 30

GPA-127

C-1 Only a few DIFM items or depot repair items in this equipment.

3.25 Subassemblies are depot repairable units

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	1		1	1	4				1	1					2					
B	1	1		1		2				1				1	1		1			1
C			2	2		2									2					2
D		2			4					1					1					2
E			1		2	1				1					2				1	1
F				1	1					3						1				1
G			1		1	2								1	2					2
TOTAL	2	3	5	5	12	7			1	7				2	10	1	1		1	9

3.26 System operational requirements are 24 hours continuous

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	7					2					2									
B	3					3					2					1	1			
C	4					2					2					2				
D	6					1					1					2				
E	3					2					2					2				
F	2					3										3				
G	3					2					3					2				
TOTAL	28					15					12					12	1			

3.27 System operation requirements are without daily preventive/scheduled maintenance.

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	3				3	1				1				1	1					
B					3	1				2					2		1			1
C		1			3					2					2					2
D					6					1					1	1				1
E					3				1	1					2					2
F					2		1		1	1										3
G	1				2					2					3					2
TOTAL	4	1			22	2	1		2	10				1	11	1	1			11

3.25 Subassemblies are depot repairable units

FPS-27A

A-1 Some subassemblies are XD2 items which the site is not authorized to fix.

3.26 System operational requirements are 24 hours continuous

FPS-27A

A-1 1 hour/day for P.M.s plus 4 - 6 hours for weekly P.M.s

3.27 System operation requirements are without daily preventive/scheduled maintenance

FPS-27A

A-1 One hour per day is scheduled for P.M.

A-2 Adequate P.M. time is furnished

C-1 Daily checks are required (every 8 hours)

GPA-127

C-1 There are both daily and 28 day P.M.s

C-2 Equipment is checked daily with no downtime and checked every month with about 3 hours of downtime for cleaning and visual inspection.

4. TOOLS

4.1 Standard/common handtools are required to perform system-level maintenance.

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	4	2			1	1	1				1			1						
B	2		1			2		1				2				1	1			
C	3	1				2					1	1				2				
D	6					1					1					2				
E	3					1		1					1		1	2				
F	2					1		1	1							3				
G	3					1	1				2			1		2				
TOTAL	23	3	1		1	9	2	3	1		5	3	1	2	1	12	1			

4.2 Special handtools are required to perform system-level maintenance

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	1			3	3		1		1		1				1					
B			1	1	1			1		2		1			1					2
C			1	1	2					2				1	1					2
D	1		3	1	1					1				1						2
E					3			1		1			1		1					2
F					2		1		1	1									1	2
G					3				1	1				1	2	1				1
TOTAL	2		5	6	15		2	2	3	8	1	1	1	3	6	1			1	11

4.3 Standard/common handtools are required to perform assembly level maintenance

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	2	3		1		1	1				1			1						
B	2		1			2		1				2				1	1			
C	1	3				2					1				1	2				
D	4	2				1						1				2				
E	3					1		1					1		1	2				
F	2					1			1							2		1		
G	3					1	1				2		1			2				
TOTAL	17	8	1	1		9	2	2	1		4	3	2	1	2	11	1	1		

4.1 Standard/common handtools are required to perform system-level maintenance

4.2 Special handtools are required to perform system-level maintenance

FPS-27A

A-1 5/65 Allen wrench required for RF amp diode removal (Ref ¼ AFLC letter

D-1 Very few special tools are required.

FYQ-47

D-1 A card puller is the only special tool for assembly. Pace equipment is necessary for cards.

4.3 Standard/common handtools are required to perform assembly level maintenance

4.4 Special handtools are required to perform assembly level maintenance

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	1	1		2	3		1		1		1				1					
B				2	1			1		2			1		1				1	1
C			1	2	1					2	1				1					2
D	1		1	2	2					1		1								2
E					3			1		1			1		1					2
F					2				1	1								1	1	1
G					3				1	1				1	2	1				1
TOTAL	2	1	2	8	15		1	2	3	8	2	1	2	1	6	1		1	2	9

4.5 Adequate quantities and types of standard/common handtools are available at the site

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	6	1				2					1	1								
B		2		1		3						2				1	1			
C	3	1				2					2					2				
D	5	1				1					1					2				
E	3					2					2						2			
F	2					1	2									2		1		
G	3					1	1				2	1				2				
TOTAL	22	5		1		12	3				8	4				9	3	1		

4.6 Adequate quantities and types of special handtools are available at the site

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	3	1	1		2	1				1	1			1						
B				1	2	2	1					1		1		1				1
C	1	1	1	1		2					2					1				1
D	4	1			1			1			1					1				1
E	2	1				2					2					1				1
F	1			1			1	1	1									1	1	1
G	2			1		1	1				2	1				1		1		
TOTAL	13	4	2	4	5	8	3	2	1	1	8	2		2		5		2	1	5

4.4 Special handtools are required to perform assembly level maintenance

FPS-27A

A-1 Special desoldering units are needed.

D-1 Dome special tools are needed for replacing Klystron as well as crimping tools for Rx.

4.5 Adequate quantities and types of standard/common handtools are available at the site

4.6 Adequate quantities and types of special handtools are available at the site

FPS-27A

A-1 Desoldering unit was manufactured locally.

C-1 Special cable repair equipment is difficult to obtain.

C-2 Crimping tools are available, but there are no instructions or crimping material.

GPA-127

F-1 Not needed

4.7 Adequate quantities and types of standard/common handtools are available at the base maintenance shop
a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	1	2		1	2	2					1				1					
B		1			1	2			1			1	1					1		1
C					1	1				1						1				
D	3				2		1									1				
E						2					2					1	1			
F	1	1								2						2		1		
G	1				1		1									1				1
TOTAL	6	4		1	7	7	2		1	3	3	1	1		1	6	1	2		2

4.8 Adequate wuantities and types of special handtools are available at the base maintenance shop
a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A		3	1		2	2					1				1					
B					1	2				1		1		1						2
C					1	1														1
D	2	1			2			1								1				
E						2					2					1	1			
F	1	1								2						1		1	1	
G	1				2		1									1				1
TOTAL	4	5	1		8	7	1	1		3	3	1		1	1	4	1	1	1	4

4.9 Standard/common handtools have to be released from handtool storerooms
a. 100 to 90%, b. 90 to 70% c. 70 to 30%, d. 30 to 10%, e. 10 o 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A		1			6					2					2					
B		1			2					3	1			1		1				1
C	1				2					2					2					1
D	1				3					1					1					2
E					2					2					2					2
F	1				1					3										3
G	1				2					1					3	1				1
TOTAL	4	2			18					14	1			1	10	2				10

4.7 Adequate quantities and types of standard/common handtools are available at the base maintenance shop

4.8 Adequate quantities and types of special handtools are available at the base maintenance shop

4.9 Standard/common handtools have to be released from handtool storerooms

FPS-27A

- C-1 Supplied tool boards are near equipment
- C-2 Tools are locked in 4001S boards in the tower.
- D-1 Tool boards are used in the shop
- D-2 Only at times when other sections require use of the tools.
- E-1 Tool boards are located in the Work Center.

FYQ-47

- D-1 Have own tools.

GPA-127

- B-1 Tool boards are used.
- C-1 Tool boards
- C-2 Tool boards in maintenance tower.

4.10 Special handtools have to be released from handtool storerooms

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A		1	1		5					2					2					
B		1			2					3	1			1						2
C		1			2					2					2					1
D	1				3					1					1					2
E					2					2					2					2
F	1				1				1	2										3
G	1				2					1					3	1				1
TOTAL	3	3	1		17				1	13	1			1	10	1				11

4.11 A complete set of tools is issued to each maintenance technician

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	1				6					2					2					
B				1	2					3				1	1					2
C					4					2					2					1
D					6					1					1					2
E					3	1				1	1				1					2
F					2					3										3
G					3					2					3					2
TOTAL	1			1	26	1				14	1			1	10					12

4.12 A complete set of tools is issued to each site

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	7					1	1				1	1								
B	1		1			2				1	1		1			2				
C	3	1				1				1	2					1				
D	4				2	1					1					2				
E	3					1									2	2				
F	2					1				1						2		1		
G	2				1	1	1			1	3					2				
TOTAL	22	1		1	3	8	2			4	8	1	1		2	11		1		

4.10 Special handtools have to be released from handtool storerooms

FPS-27A

C-1 Most special tools are kept in locked tool board in tower.

E-1 Tool boards are located in Work Center.

GPA-127

C-1 Tool boards.

4.11 A complete set of tools is issued to each maintenance technician

FPS-27A

A-1 Receiver floor is equipped with a tool board with all necessary tools available to all techs.

A-2 Tool boards are available, which contain most of the common tools, for all techs.

B-1 Tool boards are in each area.

C-1 Tool boards available.

D-1 Tool boards are used.

GPA-127

C-1 Tool boards.

C-2 Tool boards.

F-1 There is a common tool board for each maintenance section.

F-2 Tool boards.

4.12 A complete set of tools is issued to each site

FPS-27A

C-1 A complete set is not required by all sites.

FYQ-47

C-1 IF ordered by shop.

D-1 Each shop has complete set of tools.

GPA-127

C-1 Tool boards.

4.13 A complete set of tools is issued to the base maintenance shop

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	3		1			1	1				1				1					
B						2		1			1			1		1				1
C						2														1
D	4					1										1				
E				1		1				1	2					2				
F	2									2						2	1			
G					3	1	1									1				1
TOTAL	9	0	1	1	3	8	2	1		3	4			1	1	7	1			3

4.14 Site handtools are described and recommended in system related handbooks

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	1	4			1	2					2									
B	1	1	1			2		1			1	1						1	1	
C	1	1		1	1	2					2					2				
D	4	2				1									1	1				
E	2	1				1				1	1				1		1	1		
F	1				1				1	1						1	1	1		
G		1	1		1	1	1				2	1				1	1			
TOTAL	10	10	2	1	4	9	1	1	1	2	8	2			2	5	3	3	1	

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A																				
B																				
C																				
D																				
E																				
F																				
G																				
TOTAL																				

4.13 A complete set of tools is issued to the base maintenance shop

GPA-124

C-1 Tool boards.

4.14 Site handtools are described and recommended in system related handbooks

FPS-27A

C-1 No recommended or needed hand tools listed.

C-2 Not all tools are listed.

5. SPARES PROVISIONING

5.1 Adequate assembly sparing is maintained in inventory

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A		3	1	3					1	1				1	1					
B		2	1			1				2			1	1						2
C	2		1		1					2		1			1					2
D	3	3								1	1						1			1
E				2	1	1				1	2									2
F		1			1	2				1						1		1		1
G	1	1			1	1				1	2	1							1	1
TOTAL	6	10	3	5	4	5			1	9	5	2	1	2	2	1	1	1	1	9

5.2 Adequate subassembly (board) sparing is maintained in inventory

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	1	4		1	1	2					1	1								
B	1	1	1			3					1	1								2
C	1	2	1			2					2									2
D	3	3					1				1					1				1
E	1	1	1			2					2									1
F		1		1		1	1									1		1		1
G		2	1			2					3									2
TOTAL	7	14	4	2	1	12	2				10	2				2		1		9

5.3 Critical assembly sparing (high failure rate units) is adequate

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	3	2			1		1		1				1		1					
B	1				2	1	1			1		1		1				1		1
C		1	1	1	1	1				1	2									2
D	5		1							1	1					1				1
E			3			1				1	2									2
F	1				1	1	1	1								1	1			1
G	1	2				1				1	2	1				1			1	
TOTAL	11	5	5	1	5	5	3	1	1	5	7	2	1	1	1	3	1	1	1	7

5.1 Adequate assembly sparing is maintained in inventory

FPS-27A

A-1 No gear train assembly, CRTs are in inventory.

GPA-124

C-1 No spares.

C-1 No spares.

5.2 Adequate subassembly (board) sparing is maintained in inventory

GPA-127

C-1 No spares

E-1 No spares.

5.3 Critical assembly sparing (high failure rate units) is adequate

FPS-27A

A-1 Difficulty in obtaining RF amps.

C-1 Log/Limit and Amp detecter module rate very low.

FYQ-47

C-1 No high failure rate items.

GPA-127

C-1 No spares.

F-1 We have no spare assembly or subassembly, but adequate bench stock.

5.4 Critical subassembly (board) sparing is adequate

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	2	3		2		1	1				1	1								
B	1				2	3					1	1								2
C		2	1	1		2					2									2
D	5	1					1				1					1				1
E	1		1	1		2					2									2
F	1			1		1	1									2	1			
G		3				1		1			2	1				1				1
TOTAL	10	9	2	5	2	10	3	1			9	3				4	1			8

5.5 Replenishing spares inventories is directly related to assembly/subassembly (board)/component demand by site or maintenance shop personnel

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	2	4			1	2					2									
B	1		1	1		3						2						1		1
C	1		1	1	1	2					2					1				1
D	5	1				1									1	1				
E	1	1		1		1				1	1				1					2
F	2					2	1									2	1			
G		1	2							2	2	1				1			1	
TOTAL	12	7	4	3	2	11	1			3	7	3			2	5	1	1	1	4

5.6 Replenishing spares inventories is directly related to spares provisioning estimates

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	1	2	1	2			1				1	1								
B	1		1	1		2			1			1	1					2		
C			2			2									1			1		1
D	3	1		1	1	1						1				1				1
E			2	1		2					2						1			1
F	1				1		1		1							1	1	1		
G			2		1	1		1			1	2				1				1
TOTAL	6	3	8	5	3	8	2	1	2		4	5	1		1	3	2	4		4

5.4 Critical subassembly (board) sparing is adequate

GPA-127

C-1 Only XB3 components are kept on hand

C-2 No spares.

5.5 Replenishing spares inventories is directly related to assembly/subassembly (board/component demand by site or maintenance shop personnel

FPS-27A

B-1 This is not always the case, particularly with critical items.

C-1 Some spares are on order for 6 months or longer.

GPA-127

C-1 No spares.

D-1 Place order with supply when needed, they in turn have to order part.

D-2 No demand for assemblies and subassemblies.

5.6 Replenishing spares inventories is directly related to spares provisioning estimates

FPS-27A

A-1 If 349s don't show consumption, the individual part is deleted from bench stock.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A																				
B																				
C																				
D																				
E																				
F																				
G																				
TOTAL																				

5.8 Replenishing spares inventories generally does impose some supply delay downtime for completing assembly repairs

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A			1		5			1		1			1		1					
B		1	1	1					3				2						1	1
C			2	1	1					2					2					2
D				4	2			1						1		1			1	
E			1	2		1				1		1			1					2
F		1	1							3								2		1
G		1	1	1						2			1		2					2
TOTAL		3	7	9	8	1		2	3	9		1	4	1	6	1		2	2	8

5.9 Administrative delay downtime (delay time other than supply delay) generally does impose retraints to replenishing spares inventories.

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A		1	2	1	3					2				1	1					
B					2			1		2			2							2
C				1	2					2	1				1					2
D			1	1	4					1					1					2
E					3		1			1				1	1					2
F				1	1					3								1		2
G				1	2					2				1	2					2
TOTAL		1	3	5	17		1	1		13	1		2	3	6			1		12

5.7 Replenishing spares inventories generally does impose some supply delay downtime for completing system repairs

5.8 Replenishing spares inventories generally does impose some supply delay downtime for completing assembly repairs

5.9 Administrative delay downtime (delay time other than supply delay) generally does impose restraints to replenishing spares inventories

FPS-27A

A-1

5.10 Discrete component sparing (common stock for resistors, capacitors, etc) is adequate

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	2	2	1	1	1		2					2								
B			1	2		1				2			2			1			1	
C	2	1	1							2	1	1				2				
D	3	3								1					1	2				
E	1	1		1		1					1		1				2			
F	1		1					1		1						1	2			
G		2	1			1				1	1	2				1	1			
TOTAL	9	9	5	4	1	3	2	1		7	3	5	3		1	7	5		1	

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A																				
B																				
C																				
D																				
E																				
F																				
G																				
TOTAL																				

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A																				
B																				
C																				
D																				
E																				
F																				
G																				
TOTAL																				

5.10 Discrete component sparing (common stock for resistors, capacitors, etc) is adequate

FPS-27A

A-1 Very little common stock is bench stocked.

B-1 If the item is used frequently during any given quarter.

C-1 Low usage rate items are systematically deleted, thus imposing added supply delay.

C-2 Good bench stock of discreet components is available

GPA-124

E-1 Do not stock components, boards are not repaired at site.

GPA-127

C-1 Bench stock is established on common stock by demand method. No demand on bench stock.

G-1 Should stock gears for drive coil assembly.

6. HANDBOOKS

6.1 Adequate copies of maintenance manuals are available at the site for system maintenance
a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	3	4				2					2									
B	1	2				3						2				1	1			
C	3	1				2					2					2				
D	6					1									1	2				
E	3					2					2					2				
F	1		1			2		1								2	1			
G	2	1				1	1				2	1				2				
TOTAL	19	8	1			13	1	1			8	3			1	11	2			

6.2 Adequate copies of maintenance manuals are available at the base maintenance shop for assembly maintenance
a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A						2					1				1					
B						1	1					2								2
C						1				1						1				
D						1										2				
E						2					2								1	1
F							1			1						2	1			
G						2										1				1
TOTAL						9	2			2	3	2			1	6	1		1	4

6.3 Maintenance manual instructions provide adequate detail in order to simply and easily perform routine maintenance
a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	3	2	2			1	1				2									
B	1		1	1		1	1	1				1		1			2			
C	2	2				1	1				1			1		2				
D	3	3				1							1			2				
E	2	1				2					2					2				
F		1	1				2	1								2		1		
G	1	1	1			1	1				1	2				1	1			
TOTAL	12	10	5	1		7	6	2			6	3	1	2		9	3	1		

6.1 Adequate copies of maintenance manuals are available at the site for system maintenance

FPS-27A

A-1 2-6 is still a preliminary T.O.

A-2 Personal handouts should be provided during training sessions.

F-1 The new T.O. schematics for the FPS-27A meet the standards of the old system. They are hard to handle and biners for them must be manufactured locally. A Tech must be familiar with the T.O. before problems in the system can be repaired. The old T.O.s were destroyed before the new system was complete and before classes on the usage of the new system were started.

6.2 Adequate copies of maintenance manuals are available at the base maintenance shop for assembly maintenance

FPS-27A

A-1 2-6 is still a preliminary T.O.

6.3 Maintenance manual instructions provide adequate detail in order to simply and easily perform routine maintenance

FPS-27A

B-1 There are numerous mistakes.

C-1 The tech's experience and familiarity has some bearing

G-1 Not all checks and alignments are correct and complete.

FYQ-47

D-1 A.F. logics are poor - time would be saved if FAA logics could be used.

6.4 Maintenance manual format is consistent with clear and concise instructional procedure

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	2	3	2				2				1	1								
B		1	1	1			2		1			1	1				1	1		
C	1	3				1	1					1		1		2				
D	4	2				1							1			2				
E	1		2			1	1				2						2			
F			2				2	1								2		1		
G		2	1				1	1			1	2				1	1			
TOTAL	8	11	8	1		3	9	2	1		4	5	2	1		7	4	2		

6.5 Maintenance manuals are generally used for assembly fault isolation at the site

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	3	3			1	1	1				1	1								
B	2	1				2	1					1			1			2		
C	2	1	1			2					1					2				
D	5			1		1					1					2				
E	1			2		1			1		1	1				2				
F		2					2		1							2			1	
G	1	2				1		1			1	2					2			
TOTAL	14	9	1	3	1	8	4	1	2		5	5			1	8	2	2	1	

6.6 Maintenance manuals are gener. .y used for subassembly (board) fault isolation at the site

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	4	2	1			2					2									
B	1	1		1		2				1		2					1	1		
C	2	1	1			2					2					2				
D	5	1				1					1					2				
E	1			2		1	1				2					2				
F			2			1	1									2			1	
G	1	1	1			1		1			1	2					2			
TOTAL	14	6	5	3		10	2	1		1	8	4				8	3	1	1	

6.4 Maintenance manual format is consistent with clear and concise instructional procedure

FPS-27A

B-1 There are numerous mistakes.

C-1 Could be improved.

F-1 There are variations between the -9 and operational T.O.s which can result in lost time due to interpretation.

GPA-124

G-1 Word description is sometimes confusing.

FYQ-47

C-1 Still have tech errors in manual.

GPA-127

F-1 Clear as any maintenance manual.

6.5 Maintenance manuals are generally used for assembly fault isolation at the site

FYQ-47

C-1 Have two units, isolation is simple.

6.6 Maintenance manuals are generally used for subassembly (board) fault isolation at the site

FPS-27A

F-1 The T.O.s available are not always adequate.

6.7 Maintenance manuals are generally of the latest issue

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	2	5				2					2									
B	1	1	1			3					1	1				2				
C	2	1		1		2					2					2				
D	5					1						1				2				
E	2	1				2					2					2				
F	2					2	1									2			1	
G	2	1				2					1	2				2				
TOTAL	16	9	1	1		14	1				8	4				12			1	

6.8 Maintenance manuals are extensively stressed during technician training for system maintenance

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	3	3	1			1	1				2									
B	2	1				2		1				1			1	1	1			
C	4					1	1				1	1				2				
D	6					1					1					2				
E	2	1				1		1			1	1				1		1		
F	2					2	1									2			1	
G	1	2				1	1				2	1				1	1			
TOTAL	20	7	1			9	4	2			7	4			1	9	2	1	1	

6.9 Approximately ____ percent of every corrective maintenance activity of the system is preoccupied with maintenance manual study

a. 100 to 80%, b. 80 to 60%, c. 60 to 40%, d. 40 to 20%, e. 20 o 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A		1		2	1	1				1		1			1		1	2		
B			1	1	1			1	1				1		1	1	1			
C	1	1	1			1	1						1			1			1	
D	4	1		1					1		1					1			1	
E		1	1						2					2						2
F	1			1	1						1	1							3	
G	1	1	1						2		1		1		1	1		1		
TOTAL	7	5	4	5	3	2	1	1	6	1	3	2	3	2	3	4	2	3	5	2

6.7 Maintenance manuals are generally of the latest issue

FPS-27A

- C-1 Maintenance personnel work with outdated manuals due to slow revisions and corrections.
- C-2 Numerous errors.
- C-3 Difficulty in obtaining manuals.

FYQ-47

- C-1 Manuals are supplemented and changed.

6.8 Maintenance manuals are extensively stressed during technician training for system maintenance

FPS-27A

- C-1 Heavy emphasis is placed on utilizing tech data.

6.9 Approximately 90 percent of every corrective maintenance activity on the system is preoccupied with maintenance manual study.

6.10 Approximately ____ percent of every corrective maintenance activity on assemblies is preoccupied with maintenance manual study

a. 100 to 80%, b. 80 to 60%, c. 60 to 40%, d. 40 to 20%, e. 20 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A		1		2	2	1		1			1		1				1	2		
B			1	1				1	1					2		2				
C	1	1	1			1	1				1			1		1			1	
D	5			1					1		1					1				1
E		2							2					2						2
F	1		1	1							1				1				3	
G		2	1						1		1		1		1	1		1		
TOTAL	7	6	4	5	2	2	1	2	5		5		2	5	2	5	1	3	4	3

6.11 Approximately ____ percent of every corrective maintenance activity on subassembly (board is preoccupied with maintenance manual study.

a. 100 to 80%, b. 80 to 60%, c. 60 to 40%, d. 40 to 20%, e. 20 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A		1		2	2	1		1			1		1				2	1		
B				2			2					1	1			1	1			
C	1		1	1						2	1				1	1			1	
D	5		1						1		1					1				1
E	1	1							1				1	1						2
F		1		1	1						2								3	
G	1	1	1							2	1		1		1	1		1		
TOTAL	8	4	3	6	3	1	2	1	2	4	6	1	4	1	2	4	3	2	4	3

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A																				
B																				
C																				
D																				
E																				
F																				
G																				
TOTAL																				

6.10 Approximately 90 percent of every corrective maintenance activity on assemblies is preoccupied with maintenance manual study

GPA-124

F-1 Have much trouble following logic of manuals

GPA-127

F-1 The percentage is much higher with trainees

6.11 Approximately 0 percent of every corrective maintenance activity on subassembly (board is preoccupied with maintenance manual study.

FYQ-47

C-1 Checkout of boards is by test set and T.O. check list.

7. PERSONNEL

7.1 System operators are required to perform fault isolation or maintenance

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	2				4					2					2					
B					3					3		2								2
C					4					2	1				1					2
D	2				4					1					1				1	1
E					3					2					2				1	1
F					2	1				2						2				1
G					3					1					3					2
TOTAL	4				23	1				13	1	2			9	2			2	9

7.2 System operators are formally trained to perform fault isolation or maintenance

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	2				3					2					2					
B					3	1				2				1						2
C					4					2	1				1					2
D	2				4					1					1	1				
E					3					2					2				1	1
F					2	1				2						2				1
G					3					1					3					2
TOTAL	4				22	2				12	1			1	9	3			1	8

7.3 System operators are trained maintenance technicians

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	2				4					2					2					
B					3	1				2				1	1					2
C					4					2	1				1					2
D	2				4					1					1					2
E					3					2					2					2
F					2	1				2						1	1			1
G					3					1					3					2
TOTAL	4				23	2				12	1			1	10	1	1			11

7.1 System operators are required to perform fault isolation or maintenance

FYQ-47

B-1 Have not been too accurate.

E-1 Understood to mean operations personnel.

GPA-127

C-1 Operators report any failure to maintenance

D-1 They notify maintenance section that a failure has occured.

7.2 System operators are formally trained to perform fault isolation or maintenance

GPA-127

D-1 They are taught to recognize a correct presentation.

7.3 System operators are trained maintenance technicians

7.4 System operators are experienced maintenance technicians

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	1		1		4					2					2					
B					3		1			2				1	1					2
C					4					2	2									2
D		2			4					1					1					2
E					3					2					2					2
F					2		1			2								1		1
G					3					1					3					2
TOTAL	1	2	1		23		2			12	2			1	9			1		11

7.5 Maintenance technicians are required to complete formal training on the system in order to qualify for system maintenance

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	3	2				1	1				2									
B	2				1	1	1		1		1			1		2				
C					4	2					2					1				1
D	4			1	1						1					2				
E					3	2					2									2
F	2					2	1									2	1			
G			1		2	1	1				2	1				1				1
TOTAL	11	2	1	1	11	9	4		1		10	1		1		8	1			4

7.6 Maintenance technicians are required to complete ? weeks of formal system training

a) None b) six or less c) 12 or less d) more than 12

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	4	0	1	2			1	1		—				2	—					—
B	1	0	0	2			3			—				2	—		1		1	—
C	2	0	0	1			2			—				2	—		2			—
D	2	1	1	1			1			—				1	—		2			—
E	3	0	0	0			1			—				2	—	2				—
F	0	0	1	1			1		1	—					—	1			1	—
G	2	1	0	0			2			—				2	—		2			—
TOTAL	14	2	3	7			11	1	1					11		3	7		2	

7.4 System operators are experienced maintenance technicians

7.5 Maintenance technicians are required to complete formal training on the system in order to qualify for system maintenance

FPS-27A

D-1 Techs attend the equipment course given by AFETS personnel before they are qualified to work on the system.

E-1 OJT is used.

GAP-127

C-1 OJT is the normal qualifing method for this equipment.

7.6 Maintenance technicians are required to complete ? weeks of formal system training.

FPS-27A

D-1 It varies with the skill of the tech.

FYQ-47

G-1 Depends if trained in school or on site.

GPA-127

C-1 Varies with tech background and workload.

7.7 Maintenance technicians are required to complete ? weeks of on-site training and/or instruction prior to qualifying for system maintenance

a) None b) Six or less c) 12 or less d) More than 12

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	1	1	3	2	–				2	–				2	–					–
B	0	0	2	1	–		1			–				1	–			1		–
C	1	1	0	0	–				2	–				2	–	1				–
D	0	0	3	1	–				1	–					–		2			–
E	0	2	1	0	–		2			–				2	–		2			–
F	0	0	2	0	–			1		–					–		3			–
G	0	2	1	0	–				1	–			1	1	–		1		1	–
TOTAL	2	6	12	4	–		3	2	6				1	8		1	8	1	1	

7.8 Maintenance technicians are required to complete ? weeks of contractor-conducted training and/or instruction prior to qualifying for system maintenance.

a) None b) Six or less c) 12 or less d) More than 12

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	5	0	1	0	–	2				–	2									–
B	1	1	1	0	–	3				–						1	1			–
C	3	0	0	0	–	2				–	2					1				–
D	4	0	1	0	–	1				–			1			1	1			–
E	2	1	0	0	–	1	1			–	2					2				–
F	2	0	0	0	–	1				–						2			1	–
G	2	1	0	0	–	1	1			–		1				1	1			–
TOTAL	19	3	3	0	–	11	2				6	1	1			8	3		1	

7.9 System maintenance technicians are required to perform assembly maintenance

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	2	2		3		2					2									
B	3					3					1	1				1				1
C	3				1	2					2					2				
D	6					1					1					2				
E	2		1			1	1				2						2			
F	2					2	1									3				
G	2	1					1				1	2				2				
TOTAL	20	3	1	3	1	11	3				9	3				10	2			1

7.7 Maintenance technicians are required to complete ? weeks of on-site training and/or instruction prior to qualifying for system maintenance.

FPS-27A

C-1 Qualification is determined by trainee's immediate supervisor. No specifix training time is required other than 6 months for level 5.

C-2 There is no set period. Techs progress at their own rate.

C-3 Techs are normally given one month per unit. (Tx, Rx)

D-1 Techs are on a continuing training basis rather than a set number of weeks before being system qualified.

FYQ-47

D-1 Some technicians take bypass tests.

G-1 Depends on technicians.

GPA-127

B-1 Whatever time needed.

C-1 Varies depends on tech.

F-1 OJT until proficient.

7.8 Maintenance technicians are required to complete ? weeks of contractor-conducted training and/or instruction prior to qualifying for system maintenance

FPS-27A

B-1 Only on initial installation.

7.9 System maintenance technicians are required to perform assembly maintenance

FPS-27A

B-1 There is no separation between system and assembly maintenance.

7.10 System maintenance technicians receive additional training to qualify for assembly maintenance
a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	1	1		2	3	2					2									
B				2	1		1	1		1		1	1							
C	2		1		1					2					2			1		1
D	2			2	2	1									1				1	1
E			1		2	2							1		1					2
F		1			1	1				1									1	2
G	2				1			1				1	1				1			1
TOTAL	7	2	2	6	11	6	1	2		4	2	2	3		4		1	1	2	7

7.11 System maintenance technicians are instructed using validated maintenance handbooks.
a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	4	2		1		2					2									
B	2		1			2				1		1	1			2				
C	3	1				2					2					2				
D	6					1					1					2				
E	3					2					2						2			
F	2					1	2									2			1	
G	2	1				2					2	1				2				
TOTAL	22	4	1	1		12	2			1	9	2	1			10	2		1	

7.12 System operators are required to achieve at least a minimum skill level rating of ?.
a) 3 b) 5 c) 7

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	2	1	0				1					1								
B	0	3	0			1	2					1				1				
C	0	1	0				1				1	1								
D	1	4	0								1						2			
E	0	2	0				1					1					2			
F	0	2	0				3										3			
G	0	1	1									3				1				
TOTAL	3	14	1			1	8				2	7				2	7			

7.10 System maintenance technicians receive additional training to qualify for assembly maintenance

FPS-27A

A-1 This additional training involves some soldering techniques for PCBs.
A-2 Techs are required to work on all assemblies. No special training is given to specific individuals.
C-1 On site training.
D-1 The T.O. is used to repair the assembly.

FYQ-47

D-1 Little or no distinction between assembly and system.

7.11 System maintenance technicians are instructed using validated maintenance handbooks

7.12 System operators are required to achieve at least a minimum skill level rating of ?.

7.13 System maintenance technicians are required to achieve at least a minimum skill level rating of ?.
a) 3 b) 5 c) 7

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	2	5	0				2					2								
B	0	3	0			1	2					1				2				
C	0	3	1				2					2						1		
D	0	5	1				1					1					2			
E	0	3	0				2					2					2			
F	0	2	0				2	1									3			
G	0	3	0				2					3					2			
TOTAL	2	24	2			1	13	1				11				2	9	1		

7.14 Assembly maintenance technicians are required to achieve at least a minimum skill level rating of ?
a) 3 b) 5 c) 7

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	2	3	0				2					2								
B	0	3	0			1	2					1				1				
C	0	2	1				2					2						1		
D	0	6	0				1					1					2			
E	0	3	0				2					2					2			
F	0	2	0				3										3			
G	0	3	0				2					3					2			
TOTAL	2	22	1			1	4					11				1	9	1		

7.15 System maintenance technicians are trained using system-related test equipment
a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	3	3			1	2					2									
B	1	1	1			2	1				1	1				1		1		
C	3	1				1		1			1				1	1				1
D	5	1				1						1				2				
E	3					1			1		1		1					2		
F	2					2				1						2			1	
G		2			1		1	1			2	1				1	1			
TOTAL	17	8	1		2	9	2	2	1	1	7	3	1		1	7	1	3	1	1

7.13 System maintenance technicians are required to achieve at least a minimum skill level rating of ?

GPA-127

C-1 In the AF the word technician is tied to a 7 level skill, any skill level works on this system.

7.14 Assembly maintenance technicians are required to achieve at least a minimum skill level rating of ?

a) 3 b) 5 c) 7

7.15 System maintenance technicians are trained using system-related test equipment

FYQ-47

C-1 Most tests are built into system.

GPA-127

C-1 No system related test equipment available.

7.16 System operators are military personnel

a. 100 to 90%, b. 90 to 70% c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	6					1					1	1								
B	3					3					1			1		2				
C	4					1				1	2					2				
D	6					1					1					2				
E	3					2					2					2				
F	2					3										3				
G	3					2					3					2				
TOTAL	27					13				1	10	1		1		13				

7.17 System operators are civilian personnel

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A					5					2				1						
B					3					3			1		1					2
C					4					2					2					2
D				1	5					1					1					2
E					3					2					2					2
F					2					3										3
G					3					2					3					2
TOTAL				1	25					15			1	1	9					13

7.18 System maintenance technicians are military personnel

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	7					1	1				1	1								
B	3					3					1	1				1	1			
C	4					2					1	1				2				
D	5	1				1					1					2				
E	3					2					2					2				
F	2					3										3				
G	3					2					3					2				
TOTAL	27	1				14	1				9	3				12	1			

7.16 System operators are military personnel

FPS-27A

A-1 One AFETS is assigned.

7.17 System operators are civilian personnel

7.18 System maintenance technicians are military personnel

7.19 System maintenance technicians are civilian personnel

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A					7				1	1				1	1					
B					3					3				1	1					2
C					4					2				1	1					2
D				1	5					1					1					2
E					3					2					2					2
F					2					3										3
G					3					2					3					2
TOTAL				1	27				1	14				3	9					13

7.20 Assembly maintenance technicians are military personnel

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	6	1				1	1				1	1								
B	1		2			3					1		1				1			
C	3				1	2					1	1				2				
D	5	1				1					1					2				
E	3					2					2					2				
F	2					3										3				
G	3					2					3					2				
TOTAL	23	2	2		1	14	1				9	2	1			11	1			

7.21 Assembly maintenance technicians are civilian personnel

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A				1	6				1	1				1	1					
B			2		1					3				1	1					1
C					4					2				1	1					2
D				1	5					1					1					2
E					3					2					2					2
F					2					3										3
G					3					2					3					2
TOTAL			2	2	24				1	14				3	9					12

7.19 System maintenance technicians are civilian personnel

FPS-27A

- A-1 We have two civilian technicians used as technical reps & trainers.
- C-1 Have two civilian technicians assigned for trainees and tech reps.
- D-1 AFETS personal are systems qualified.

7.20 Assembly maintenance technicians are military personnel

7.21 Assembly maintenance technicians are civilian personnel

GPA-127

- F-1 No difference between system and assembly tech.

7.22 System operators are career-oriented personnel

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
[illegible]	1	1	3					1		1		1								
B			1	2			1		1				1	1				1		
C	1		1	1				2		1		1		1				2		
D			4	2									1			1		1		
E		1	2			1				1	1						1	1		
F		1	1				1	1										3		
G	1	1			1			2					3				1			1
TOTAL	3	4	12	5	1	1	2	6	1	3	1	2	5	2		1	2	8		1

7.23 System maintenance technicians are career-oriented personnel

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	2	2	2	1		1	1				1	1								
B			1	2				2				1	1					2		
C			2	2				3			1			1				2		
D	2	1	2	1					1				1			1		1		
E		1	2			1			1		1		1				1	1		
F		1	1					2										3		
G		1	2					2					3				1	1		
TOTAL	4	6	12	6		2	1	9	2		3	2	6	1		1	2	10		

7.24 Assembly maintenance technicians are career-oriented personnel

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	2	2	2	1		1	1				1	1								
B			2	1				3					2					1		
C			2	1	1			2				1		1				1	1	
D	1		4						1				1			1		1		
E		1	2			1			1		1		1				1	1		
F		1	1					2										3		
G		1	2					2					3				1	1		
TOTAL	3	5	15	3	1	2	1	9	2		2	2	7	1		1	2	8	1	

7.22 System operators are career-oriented personnel

7.23 System maintenance technicians are career-oriented personnel

C-1 Number off experienced technicians with 4 or more years experience are decreasing. Maintenance depends on younger newly trained personnel.

7.24 Assembly maintenance technicians are career-oriented personnel

8. TEST EQUIPMENT

8.1 System test capability provides complete built-in test for assembly fault isolation

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A		2		4	1		1		1			1	1							
B		1	1	1			1			2			1	1						2
C			2	1	1			2			1		1							2
D	3	1	2							1			1					1		1
E		1		2				2				2								2
F			1	1			2												1	2
G		2		1					2		1	2								2
TOTAL	3	7	6	10	2		4	4	3	3	2	5	4	1				1	1	11

8.2 Assembly test capability provides complete built-in test for lower level fault isolation

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A			3	2	2		1	1					1	1						
B		1	1	1				1	1				1	1						1
C		1	1	1	1			1		1		1			1					2
D		3	3							1			1					1		1
E				2	1				2				1		1					2
F			1	1			2													3
G		1			1				1	1		1	1		1					2
TOTAL		6	9	7	5		3	3	4	3		2	5	2	3			1		11

8.3 System test equipment is available at the site when needed

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	3	3	1			1	1				2									
B		1	1			2			1		1		1			1	1			
C	2	2				2					2					2				
D	6						1					1				1		1		
E	1	2				2					1	1				2				
F	2						3									2	1			
G	1	2				2					1	2				1	1			
TOTAL	15	10	2			9	5		1		7	4	1			9	3	1		

8.1 System test capability provides complete built-in test for assembly fault isolation

A-1 There is no complete built-in-test for F-1 with built-in-test now in equipment, can check over all operation only

GPA-127

D-1 Scope presentation is only clue to malfunction.

8.2 Assembly test capability provides complete built-in test for lower level fault isolation

A-1 There is no complete built-in-test for F-1. Available test features provide overall operational check only.

A-2 Normally one of the high beam channels are used.

8.3 System test equipment is available at the site when needed

C-1 Malfunction and slow return from PMEL results in system degradation, due to lack of required test equipment.

8.4 System test equipment is available at the base maintenance shop when needed

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	1				1	1	1				1				1					
B		1								1	1		1			1				
C	1					1				1						1				
D	5				1		1									2				
E					1	2						1	1			2				
F		1								2						2	1			
G					1	1				1							1			1
TOTAL	7	2			4	5	2			5	2	1	2		1	8	2			1

8.5 Assembly test equipment is available at the site when needed

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	3	2	1	1		2					2									
B		1	1	1		1	1			1		1	1			1				
C		4				1				1	2					2				
D	6						1					1				2				
E	1	2				2					1	1				2				
F	2						3									2	1			
G	1	2				2					1	2				1	1			
TOTAL	15	11	2	2		8	5			2	6	5	1			10	2			

8.6 Assembly test equipment is available at the base maintenance shop when needed

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	1		1		1	2					1				1					
B			2							1		1	1			1				
C					1					2						1				
D	1	1					1									2				
E						2						1	1			2				
F					1					2						2	1			
G					3	1				1							1			1
TOTAL	2	1	3		6	5	1			6	1	2	2		1	8	2			1

8.4 System test equipment is available at the base maintenance shop when needed

8.5 Assembly test equipment is available at the site when needed

C-1 Could use more static test procedures

8.6 Assembly test equipment is available at the base maintenance shop when needed

8.7 Subassembly (board) test equipment is available at the site when needed

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	3	3			1	1			1		2									
B		1	1							3	1	1				1		1		
C	1		1	1	1				1	1	2					2				
D	4	1	1				1				1					1	1			
E	1	1	1			1					2					2				
F	1	1				1	1		1							2				1
G		2			1					2	2	1					1			1
TOTAL	10	9	4	1	3	3	2		3	6	10	2				8	2	1		2

8.8 Subassembly (board) test equipment is available at the base maintenance shop when needed

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	1	1				1			1		1				1					
B			1							2	1		1			1				
C					1				1	1						1				
D	1	1					1									1	1			
E		1			1	1					2					2				
F			1	1	1					2						1				1
G					2					2							1			1
TOTAL	2	3	2	1	7	2	1		2	7	4		1		1	6	2			2

8.9 Contractor-recommended system test equipment is available in the logistic inventory

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	4	1				1		1			2									
B		1		1	1	1				2		2				1				
C	1	1		1		2					2									2
D	4	2				1										2				
E	1	1				1				1	1					2				
F		1					1	1								2				
G		2			1	1				1	2	1							1	2
TOTAL	10	9		2	2	7	1	2		4	7	3				7			1	4

8.7 Subassembly (board) test equipment is available at the site when needed

A-1 Circuit board are checked in equipment on extender boards. No other facilities are available.
B-1 Receiver has to be used for testing, this can only be done during scheduled down time.
C-1 Test equipment not available for FPS-27A receiver boards. Circuit boards must be checked in equipment with power on.

GPA-124
E-1 No boards tested or repaired

8.8 Subassembly (board) test equipment is available at the base maintenance shop when needed

8.9 Contractor-recommended system test equipment is available in the logistic inventory

A-1 Test equipment not in inventory.
B-1 Test equipment available to maintain computers is 100% better than for the radar equipment.

8.10 Test equipment availability is adequate to accommodate every corrective maintenance activity
a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	3	2		2		1	1				2									
B	1			1	1	2	1					2					2			
C		2	2			2					2					1	1			
D	2	4					1					1				2				
E	1	1	1			2					2					1	1			
F	1	1					3									2			1	
G		3				1	1				2	1				1	1			
TOTAL	8	13	3	3	1	8	7				8	4				7	5		1	

8.11 Test equipment availability is adequate to accommodate every preventive maintenance activity
a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	3	2		2		2					2									
B	1			1	1	3						1	1			1	1			
C		2	2			2					2					2				
D	4	2				1						1				2				
E	1	2				2					1	1				1	1			
F	2					1	1	1								2		1		
G		3				2					2	1				2				
TOTAL	11	11	2	3	1	13	1	1			7	4	1			10	2	1		

8.12 Test equipment most readily available when needed for corrective maint. can be identified in the following sequential order: (ordered from most frequent, 1, to least frequent, 10, includes items in 8.12(a))
a) waveform generators, b) spectrum analyzers, c) power supplies, d) frequency measurement devices, e) volt/amp meters.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	4	2	2	5	7															
B	9	2	2	2	6															
C	8	5	9	4	10															
D	3	5	4	6	10															
E	4	2	2	7	9															
F	—	—	—	—	—															
G	5	1	2	4	9															
TOTAL	6	2	3	4	9															

NOT CONSISTENTLY COMPLETED
NOT SUMMARIZED

8.10 Test equipment availability is adequate to accommodate every corrective maintenance activity

A-1 Ocilloscopes with 30 MHz response are not available at this site.
C-1 Substitutions are often used.
C-2 Have difficulty obtaining some test equipment.
C-3 Have long wait for test equipment and T.E. parts.

FYQ-47
D-1 Some of our signal generators and meters are inadequate for proper maintenance.

8.11 Test equipment availability is adequate to accommodate every preventive maintenance activity

A-1 Ocilloscopes with 30MHz response are not available at this site.
C-1 Substitutions are often used.
C-2 Have difficulty obtaining some test equipment.
C-3 Have long wiat for test equipment & test equipment parts.

8.12 Test equipment most readily available when needed for corrective maintenance can be identified in the following sequential order: (ordered from most frequent, 1, to least frequent, 10, includes items in 8.12(a))

FYQ-47
A chart recorder and a frequency counter would be very useful.

8.12a Test equipment most readily available when needed for corrective maintenance can be identified in the following sequential order:

a) oscilloscopes, b) RF devices, c) RF cables, d) VSWR meters, e) power meters

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	10	7	9	1	6			NOT CONSISTENTLY COMPLETED												
B	10	5	7	1	8															
C	7	2	5	3	1				NOT SUMMARIZED											
D	9	1	7	1	8															
E	10	6	8	1	5															
F	–	–	–	–	–															
G	10	7	8	3	6															
TOTAL	10	5	8	1	7															

8.13 Test equipment calibration scheduling is a factor with regard to routine equipment availability

a. 100 to 90%, b. 90 to 70%, c. 70 to 30%, d. 30 to 10%, e. 10 to 0% of time.

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A	1	1	1	2	2		1				1			1						
B		1	1	1		1	1		1				1				1	1		
C		1	2		1	1		1							1			1		1
D	1	1	1	1	2	1						1				1				1
E		1	1		1	1				1	1			1				1		1
F	2						1			2						1	1	1		
G				1	1				2			1		2		1		1		
TOTAL	4	5	6	5	7	4	3	1	3	3	2	3	1	5	1	3	2	5		3

SYSTEM	FPS-27A					GPA-124					FYQ-47					GPA-127				
SITE	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
A																				
B																				
C																				
D																				
E																				
F																				
G																				
TOTAL																				

APPENDIX C

WESTINGHOUSE QUESTIONNAIRE RESPONSE SUMMARY

This appendix summarizes the answers to the Westinghouse Questionnaires. Answers to each question are given in terms of both base and equipment. Pertinent Air Force comments which can give further insight to a particular question have also been included as part of this summary.

		Quantitati			
		By Base (% of Time)			
	Base	100-90	90-70	70-30	30-10
1.1 Are all failures reported on 349 forms.	E	67	33		
	F	38	50	12	
	Av.	71	23	6	
1.2 Are failures grouped when reported or are they fixed and reported individually (as they occur).	E	75	25		
	F	75	25		
	Av.	77	19	3	1
1.3 Are failures fixed in periods of preventive maintenance.	E			22	33
	F		25	63	12
	Av.	6	22	31	24
1.4 Is this system kept operational while failures in redundant units have occurred.	E	89		11	
	F	38	25	25	
	Av.	59	13	9	3
1.5 Is this system maintained (unscheduled maintenance) while these failed units are being fixed.	E	67		11	
	F	29	14	43	
	Av.	51	10	15	8
1.6 Failures that occur are component failures.	E	33	45	11	
	F	12	88		
	Av.	45	37	6	6
1.7 Failures that occur are wiring/chassis failures.	E				
	F		12	13	25
	Av.	3	1	9	21
1.8 Failures that occur are generally one component failures.	E	22	56	11	11
	F	12	25	38	13
	Av.	29	30	22	13
1.9 When more than one failure occurs, they occur in more than one subassembly.	E		11	11	11
	F	12	12	38	13
	Av.	3	10	14	22

Q

Quantitative Response (Normalized)

me)			by Equipment (% of Time)											
0	30-10	10-0	Eqpt.	100-90	90-70	70-30	30-10	10-0	Eqpt.	100-90	90-70	70-30	30-10	10-(
			-124	80	20									
			-127(V)	62	23	15								
			Av.	71	23	6								
			-124	100					-27A	78	15	4	3	
			-127(V)	54	38	8			-47	73	27			
	1		Av.	77	19	3	1							
	33	45	-124	7	15	23	38	15						
	12		-127(V)		31	46	15	8						
	24	17	Av.	6	22	31	24	17						
			-124	46	7	7	7	33						
		12	-127(V)	62	23			15						
	3	16	Av.	59	13	9	3	16						
		22	-124	50		8	21	21						
		[illegible]	-127(V)	38	8	15	8	31						
	8	16	Av.	51	10	15	8	16						
		1	-124	40	33		7	20						
			-127(V)	54	15	15	8	8						
	6	6	Av.	45	37	6	6	6						
		100	-124	6	7	20	7	60						
	25	50	-127(V)	7			31	62						
	21	66	Av.	3	1	9	21	66						
	11		-124	50	19	13	12	6						
	13	12	-127(V)	15	16	46	15	8						
	13	6	Av.	29	30	22	13	6						
	11	67	-124	7	13	7	20	53						
	13	25	-127(V)		8	23	23	46						
	22	51	Av.	3	10	14	22	51						

TABLE 34

QUESTIONNAIRE RESPONSE SUMMARY

10-0	Eqpt.	100-90	90-70	70-30	30-10	10-0	Technician's Comment
							Base F, AN/GPA-127(V) comment - "Many failures cause time loss of less than 3 min. and and requires no JCN."
	-27A -47	78 73	15 27	4	3		
15 8 17							
33 15 16							
21 31 16							
20 8 6							
60 62 66							
6 8 6							
53 46 51							

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	Quantitative Respo						
	By Base (% of Time)						
	Base	100-90	90-70	70-30	30-10	10-0	Eq
1.10 Environment (cold, heat, rain) contribute to the maintenance problem.	E F Av.	 4	 12 12	 12 21	11 38 18	89 38 45	-12 -12 Av.
1.11 While performing maintenance, physical proximity (upstairs, downstairs, base) contributes to the unscheduled maintenance down times.	E F Av.	 1	22 6	22 25 14	 12 10	56 63 69	-12 -12 Av.
1.12 Do all technical manuals for equipments have similar formats such that, when required, procedures can be located without unnecessary delay.	E F Av.	34 12 32	22 38 30	 13 11	22 25 15	22 12 12	-12 -12 Av.
1.13 Are tech manuals of sufficient clarity to facilitate maintenance.	E F Av.	33 12 29	45 25 43	 13 13	22 25 10	 25 5	-12 -12 Av.
1.14 Do administrative activities (leave, K.P., etc.) influence maintenance times?	E F Av.		 1	11 25 8	 50 22	89 25 69	-12 -12 Av.
1.15 Do any base safety regulations hinder maintenance?	E F Av.	 2			11 10	89 100 88	-12 -12 Av.
1.16 Do any equipment designed safety procedures hinder maintenance?	E F Av.	 1		 2	11 38 21	89 62 76	-12 -12 Av.
1.17 Do all phases of maintenance have adequate light for visibility?	E F Av.	67 25 47	 38 23	33 12 15	 12 12	 12 3	-12 -12 Av.
1.18 Does equipment have enough working area (distance from walls) such that there is adequate working space when performing maintenance?	E F Av.	56 25 42	22 50 36	11 9	11 13 9	 12 4	-12 -12 Av.

1

2

itative Response (Normalized)															
		By Equipment (% of Time)													
10	10-0	Eqpt.	100-90	90-70	70-30	30-10	10-0	Eqpt.	100-90	90-70	70-30	30-10	10-0		
	89	-124	13	7	27	13	40	-27A	22	30	18	30			
	38	-127(V)	8			23	69	-47		8	17	19	58		
	45	Av.	4	12	21	18	45								
	56	-124					100	-27A	3	7	11	18	61		
	63	-127(V)		16	38	8	38	-47			8	8	84		
	69	Av.	1	6	14	10	69								
	22	-124	43	22	14	7	14								
	12	-127(V)	38	38	8	16									
	12	Av.	32	30	11	15	12								
		-124	27	47	13	7	6								
	25	-127(V)	46	38	8	8									
	5	Av.	29	43	13	10	5								
	89	-124		6	6	19	69								
	25	-127(V)			8	23	69								
	69	Av.		1	8	22	69								
	89	-124	7			7	86								
	100	-127(V)					100								
	88	Av.	2			10	88								
	89	-124	7			20	73								
	62	-127(V)				8	92								
	76	Av.	1		2	21	76								
		-124	80	20				-27A	29	32	21	11	7		
	12	-127(V)	54	8	15	23		-47	42	25	16	17		Base E, keep OP	
	3	Av.	47	23	15	12	3							- "When	
		-124	36	43	7	14									
	12	-127(V)	31	38	15	8	8								
	4	Av.	42	36	9	9	4								

2

TABLE 34. (Continued)

100-90	90-70	70-30	30-10	10-0	Technician's Comments
22	30 8	18 17	30 19	58	
3	7	11 8	18 8	61 84	
29 42	32 25	21 16	11 17	7	Base E, AN/GPA-127(V) comment - "Hampered by having to keep OPS room dimly lit." Base F, AN/GPA-127(V) comment - "When fixed lighting inadequate, drop cord lights are used."

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	Quantitative Respo						
	by Base (% of Time)						
	Base	100-90	90-70	70-30	30-10	10-0	E
1.19 When performing maintenance, does one man read instructions to other man who is in equipment performing necessary unscheduled maintenance.	E		33	34	22	11	-
	F	25	12	25	38		-
	Av.	19	38	23	16	4	A
1.20 What personnel improvements would you suggest to minimize system downtime. (a) more training, (b) better handbooks, (c) less paperwork, (d) more spares, (e) more motivation.	E	36	18	14	9	23	-
	F	20	20	13	13	7	-
	Av.	31	16	16	11	11	A
1.21 Generally, how much on-duty time involves writing failure reports.	E				22	78	-
	F			25	75		-
	Av.		2	10	50	38	A
1.22 What system improvements would you suggest to minimize system downtime. (a) more test points, (b) improved logistic support, (c) improved packaging, (d) more quick-release fasteners.	E	13	4	22	13		-
	F	14	14	14	10		-
	Av.	14	14	14	14		A
1.23 What kind of failures are not reported on 349 forms. (a) secondary, (b) test equipment, (c) other.	E		86	14			-
	F	18	64	18			-
	Av.	11	77	10		2	A
1.24 Are secondary failures reported as part of original failures.	E	11	22	45		22	-
	F	29	14	14	29	14	-
	Av.	20	17	20	20	23	A
1.25 When do most failures seem to occur. (a) morn., (b) afternoon, (c) evening.	E		50	50			-
	F	24	38	38			-
	Av.	16	42	42			A
1.26 What percentage of "can-not-duplicate" failures occur for line replaceable units.	E				56	44	-
	F		14		57	29	-
	Av.	2	5	12	39	42	A

10-0	Eqpt.	100-90	90-70	70-30	30-10	10-0	Eqpt.	100-90	90-70	70-30	30-10	10-0	
11	-124	25	50	13	12								
	-127(V)	15	23	31	23	8							
4	Av.	19	38	23	16	4							
23	-124	41	25	9	6	12							
7	-127(V)	30	13	10	17	20							
11	Av.	31	16	16	11	11							
78	-124			20	27	53							
	-127(V)			8	54	38							
38	Av.		2	10	50	38							
	-124	12	3	21	27								
	-127(V)	19	19	9	3								
	Av.	14	14	14	14								
	-124	18	64	9		9							
	-127(V)	8	92										
2	Av.	11	77	10		2							
22	-124	23		8	23	46							Base F
14	-127(V)	23	31	31	8	7							tenance
23	Av.	20	17	20	20	23							same ti
	-124	21	50	29									
	-127(V)	25	25	50									
	Av.	16	42	42									
44	-124			8	46	46							
29	-127(V)			8	46	46							
42	Av.	2	5	12	39	42							

QUESTIONNAIRE RESPONSE SUMMARY (Continued)

100-90	90-70	70-30	30-10	10-0	Technician's Comments
					Base F, AN/GPA-127(V) comment 1 "...Most maintenance personnel fix original & secondary problem at same time, with all time taken against original problem."

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3

	Quantitative Response (Norm							
	by Base (% of Time)						by	
	Base	100-90	90-70	70-30	30-10	10-0	Eqpt.	1
1.27 How often do failures occur when conducting preventive/scheduled maintenance.	E				33	67	-124	
	F				50	50	-127(V)	
	Av.		5	9	36	50	Av.	
1.28 How often do system intermittent failures occur.	E			11		89	-124	
	F		12	13	50	25	-127(V)	
	Av.		5	12	39	44	Av.	
1.29 Are intermittent failures reported as legitimate failures.	E	11		11	45	33	-124	2
	F		25	12	25	38	-127(V)	1
	Av.	19	11	14	25	31	Av.	1
1.30 When a failure occurs during preventive/scheduled maintenance are the repair and schedule tasks reported as a combined effort.	E	11		22	22	45	-124	3
	F		14	14	29	43	-127(V)	1
	Av.	22	16	12	19	31	Av.	2
1.31 Do you feel most failures are caused by thermal or electrical stress. (a) thermal, (b) electrical, (c) no opinion.	E		56	44			-124	3
	F	50	17	33			-127(V)	2
	Av.	36	34	30			Av.	3
2.1 External access is adequate for: (a) visual and manipulative tasks, (b) visual but not manipulative tasks, (c) manipulative but not visual tasks, (d) neither visual or manipulative tasks.	E	57	43				-124	7
	F	62	38				-127(V)	5
	Av.	70	25		5		Av.	7
2.2 External latches and/or fasteners: (a) are captive, need no special tools, and require only a fraction of a turn for release, (b) meet two of the above three criteria, (c) meet one or more of the above three criteria.	E	72	14	14			-124	2
	F	38	38	24			-127(V)	5
	Av.	54	34	12			Av.	5
2.3 Internal latches and or fasteners: (a) are captive, need no special tools, and require only a fraction of a turn for release, (b) meet two of the above three criteria, (c) meet one or more of the above three criteria.	E	43	14	43			-124	1
	F	12	50	38			-127(V)	5
	Av.	38	46	16			Av.	3
2.4 Internal access is adequate for: (a) both visual and manipulative tasks, (b) visual but not manipulative tasks, (c) manipulative but not visual tasks, (d) neither visual or manipulative tasks.	E	80	20				-124	5
	F	60	20	20			-127(V)	
	Av.	69	10	4	17		Av.	6

onse (Normalized)												
by Equipment (% of Time)												Technician
Eqpt.	100-90	90-70	70-30	30-10	10-0	Eqpt.	100-90	90-70	70-30	30-10	10-0	
-124				13	87							
-127(V)		8		38	54							
Av.		5	9	36	50							
-124		6	7	27	60							
-127(V)			15	54	31							
Av.		5	12	39	44							
-124	27		6	27	40							
-127(V)	17	25	16	25	17							
Av.	19	11	14	25	31							
-124	38	16	8		38							
-127(V)	15	8	8	15	54							
Av.	22	16	12	19	31							
-124	36	21	43									
-127(V)	25	50	25									
Av.	36	34	30									
-124	78	22										
-127(V)	54	46										
Av.	70	25		5								
-124	22	45	33									
-127(V)	54	23	23									
Av.	54	34	12									
-124	11	56	33									
-127(V)	54	23	23									
Av.	38	46	16									
-124	56	11	22	11								
-127(V)												
Av.	69	10	4	17								

2

							Technician's Comments
0-0	Eqpt.	100-90	90-70	70-30	30-10	10-0	
7 4 0							
0 1 4							
0 7 1							
8 4 1							

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	Quantitative Response (Norm						
	by Base (% of Time)						30
	Base	100-90	90-70	70-30	30-10	10-0	Eqp
3.1 System repair is accomplished by replacing faulty assemblies with an identical operational spare.	E		11	11		78	-12
	F	25		37		38	-12
	Av.	17	17	9	11	46	Av.
3.2 System repair is accomplished by repairing faulty subassemblies (boards) through replacement of identical operational spare.	E	22	11	22		45	-12
	F	25	12	25		38	-12
	Av.	34	15	19	5	27	Av.
3.3 System repair is accomplished at the site.	E	100					-12
	F	75	25				-12
	Av.	81	15	3		1	Av.
3.4 System repair is accomplished at a remote ship.	E	11				89	-12
	F					100	-12
	Av.	6	1		6	87	Av.
3.5 System repair is accomplished at a depot (Military or otherwise).	E					100	-12
	F				12	88	-12
	Ar.	1			5	94	Av.
3.6 Assembly repair is accomplished at the site.	E	56	11	22		11	-12
	F	75	25				-12
	Av.	68	15	7	3	7	Av.
3.7 Assembly repair is accomplished at a remote shop.	E	11			11	78	-12
	F					100	-12
	Av.	6	3		3	88	Av.
3.8 Assembly repair is accomplished at a depot (Military or otherwise).	E			22	11	67	-12
	F				12	88	-12
	Av.	3	1	3	6	87	Av.
3.9 Subassembly (board) repair is accomplished at the site.	E	89				11	-12
	F	88	12				-12
	Av.	73	9	3		15	Av.
3.10 Subassembly (board) repair is accomplished at a remote shop.	E					100	-12
	F					100	-12
	Av.	4	3	1	3	89	Av.

Response (Normalized)

		by Equipment (% of Time)												
-10	10-0	Eqpt.	100-90	90-70	70-30	30-10	10-0	Eqpt.	100-90	90-70	70-30	30-10	10-0	
	78	-124	36	7	7		50							
	38	-127(V)	8	8		8	76							
	46	Av.	17	17	9	11	46							
	45	-124	50	21			29							
	38	-127(V)	8	7			85							
	27	Av.	34	15	19	5	27							
		-124	79	14			7	-27A	71	25	4			
		-127(V)	100					-47	83	8	9			
	1	Av.	81	15	3		1							
	89	-124	27				73	-27A				11	89	
	100	-127(V)		8			92	-47				8	92	
	87	Av.	6	1		6	87							
	100	-124	6			6	88							
	88	-127(V)					100							
	94	Av.	1			5	94							
	\11	-124	53	13	7		27	-27A	61	21	14	4		
		-127(V)	92				8	-47	75	17		8		
	7	Av.	68	15	7	3	7							
	78	-124	20				80							
	100	-127(V)		8			92							
	88	Av.	6	3		3	88							
	67	-124	7		7	7	79	-27A	4	3	4	11	78	
	88	-127(V)					100	-47					100	
	87	Av.	3	1	3	6	87							
	11	-124	33	14			53	-27A	75	14	4		7	Base
		-127(V)	100					-47A	92		8			are s
	15	Av.	73	9	3		15							
	100	-124	20				80							
	100	-127(V)		8			92							
	89	Av.	4	3	1	3	89							

2

TABLE 34. (Continued)

0	Eqpt.	100-90	90-70	70-30	30-10	10-0	Technician's Comments
	-27A -47	71 83	25 8	4 9			
	-27A -47				11 8	89 92	
	-27A -47	61 75	21 17	14	4 8		
	-27A -47	4	3	4	11	78 100	
	-27A -47A	75 92	14	4 8		7	Base G, AN/GPA-124 comment - "Boards are sent to depot for repair."

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	Quantitative Respon					
	by Base (% of Time)					
	Base	100-90	90-70	70-30	30-10	10
3.11 Subassembly (board) repair is accomplished at a depot (Military or otherwise).	E	11			11	7
	F				12	8
	Av.	15	2		7	7
3.12 Subassembly (board) repair is accomplished by replacing faulty subassemblies.	E	44				5
	F		12			8
	Av.	28	7	7	4	5
3.13 Subassembly (board) repair is accomplished by replacing faulty discrete components.	E	45	11		22	2
	F	75			25	
	Av.	56	15	3	10	1
3.14 Site personnel repair the system.	E	100				
	F	88	12			
	Av.	93	6			1
3.15 Site personnel repair the assembly.	E	100				
	F	88	12			
	Av.	86	7	1		6
3.16 Troubleshooting the system requires supportive test equipment.	E	22	34	22	11	11
	F	57	29	14		
	Av.	48	36	7	6	3
3.17 Isolating to faulty assembly requires supportive test equipment.	E	45	11	11	22	11
	E	63		25		12
	Av.	53	24	8	9	6
3.18 Spare assemblies are available at the site.	E	11	11	11	22	45
	F		38			62
	Av.	16	21	7	10	46

ve Response (Normalized)													
		by Equipment (% of Time)											
30-10	10-0	Eqpt.	100-90	90-70	70-30	30-10	10-0	Eqpt.	100-90	90-70	70-30	30-10	10-0
11	78	-124	53			20	27	-27A	7	4		7	82
12	88	-127(V)					100	-47					100
7	76	Av.	15	2		7	76						
	56	-124	43	7	7		43						
	88	-127(V)	8				92						
4	54	Av.	28	7	7	4	54						
22	22	-124	47			13	40						
25		-127(V)	62	15		15	8						
10	16	Av.	56	15	3	10	16						
		-124	87	7			6						
		-127(V)	100										
	1	Av.	93	6			1						
		-124	67	6			27						
		-127(V)	100										
	6	Av.	86	7	1		6						
11	11	-124	73	20		7							
		-127(V)	46	39	15								
6	3	Av.	48	36	7	6	3						
22	11	-124	87	7		6							
	12	-127(V)	31	31	15	15	8						
9	6	Av.	53	24	8	9	6						
22	45	-124	27	13		7	53	-27A	11	32	10	18	29
	62	-127(V)	8				92	-47	25	25	17	8	25
10	46	Av.	16	21	7	10	46						

TABLE 34. (Continued)

Eqpt.	100-90	90-70	70-30	30-10	10-0	Technician's Comments
-27A -47	7	4		7	82 100	
-27A -47	11 25	32 25	10 17	18 8	29 25	Base C, AN/GPA-127(V) comment - "Other than cannibilization there are no assem. spares."

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3

	Quantitative Respo						
	by Base (% of Time)						
	Base	100-90	90-70	70-30	30-10	10-0	E
3.19 Spare subassemblies (boards) are available at the site.	E	56		11	11	22	-
	F	25	25	12		38	-
	Av.	40	25	10	6	19	A
3.20 Spare assemblies are available at the Base Maintenance Shop.	E	17	16			67	-
	F					100	-
	Ar.	3	6		3	88	A
3.21 Spare subassemblies (boards) are available at the Base Maintenance Shop.	E	50				50	-
	F					100	-
	Av.	25			3	72	A
3.22 Spare assemblies may be obtained from ship supply without a direct exchange of an identical faulty unit.	E	50			12	38	-
	F					100	-
	Av.	21	5	2	6	66	A
3.23 Spare subassemblies may be obtained from shop supply without a direct exchange of an identical faulty unit.	E	63			12	25	-
	F				12	88	-
	Av.	37	5	3	7	48	A
3.24 Assemblies are depot repairable units.	E			11	33	56	-
	F	14			29	57	-
	Av.	13	9	8	19	51	A
3.25 Subassemblies are depot repairable units.	E	11		11	11	67	-
	F	14			14	72	-
	Av.	15	5	8	14	58	A
3.26 System operational requirements are 24 hours continuous.	E	100					-
	F	100					-
	Av.	98	2				A
3.27 System operation requirements are without daily preventive/scheduled maintenance.	E				11	89	-
	F		12		13	75	-
	Av.	11	5		3	81	A
4.1 Standard/common handtools are required to perform system-level maintenance.	E	67		22		11	-
	F	75		12	13		-
	Av.	72	12	8	5	3	A

ative Response (Normalized)														
		by Equipment (% of Time)												
0	10-0	Eqpt.	100-90	90-70	70-30	30-10	10-0	Eqpt.	100-90	90-70	70-30	30-10	10-0	
	22	-124	87	13				-27A	11	46	25	14	4	
	38	-127(V)	8				92	-47	83	17				
	19	Av.	40	25	10	6	19							
	67	-124					100							
	100	-127(V)		9			91							
	88	Av.	3	6		3	88							
	50	-124	33				67							
	100	-127(V)					100	-47	50			17	33	
	72	Av.	25			3	72							
	38	-124	7				93	-27A	28	12	4	8	48	
	100	-127(V)	7			8	85	-47	46			9	45	
	66	Av.	21	5	2	6	66							
	25	-124	47			13	40	-27A	37	11	4	7	41	
	88	-127(V)	7			8	85	-47	55	7	7	4	27	Base E,
	48	Av.	37	5	3	7	48							operativ also boa
	56	-124	27	7		13	53							
	57	-127(V)	17	8		17	58							
	51	Av.	13	9	8	19	51							
	67	-124	47			7	47	-27A	7	11	19	19	44	
	72	-127(V)	8	9		8	75	-47				17	83	
	58	Av.	15	5	8	14	58							
		-124	100											
		-127(V)	92	8										
		Av.	98	2										
	89	-124	13	7		13	67							
	75	-127(V)	8	7			85							
	81	Av.	11	5		3	81							
	11	-124	60	13	20	7								
		-127(V)	92	8										
	3	Av.	72	12	8	5	3							

2

10-0	Eqpt.	100-90	90-70	70-30	30-10	10-0	Technician's Comments
 92 19	-27A -47	11 83	46 17	25	14	4	
100 91 88							
67 100 72	-47	50			17	33	
93 85 66	-27A -47	28 46	12	4	8 9	48 45	
40 85 48	-27A -47	37 55	11 7	4 7	7 4	41 27	Base E, AN/GPA-124 comment- "Non-operative boards replaced with new ones, also boards used as troubleshooting aids."
53 58 51							
47 75 58	-27A -47	7	11	19	19 17	44 83	
67 85 81							
3							

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3

	Quantitative Response (Nor						
	by Base (% of Time)						
	Base	100-90	90-70	70-30	30-10	10-0	E
4.2 Special handtools are required to perform system-level maintenance.	E			22		78	-1
	F		12		25	63	-1
	Av.	5	4	12	19	60	Av
4.3 Standard/common handtools are required to perform assembly level maintenance.	E	67		22		11	-1
	F	72		14	14		-1
	Av.	62	19	11	4	4	Av
4.4 Special handtools are required to perform assembly level maintenance.	E			22		78	-1
	F			14	29	57	-1
	Av.	7	4	11	21	57	Av
4.5 Adequate quantities and types of standard/common handtools are available at the site.	E	78	22				-1
	F	62	25	13			-1
	Av.	75	22	2	1		Av
4.6 Adequate quantities and types of special hand-tools are available at the site.	E	78	11			11	-1
	F	12	12	25	38	13	-1
	Av.	50	13	9	12	16	Av
4.7 Adequate quantities and types of standard/common handtools are available at the base maintenance shop.	E	83	17				-1
	F	43	14	14		29	-1
	Av.	48	16	6	3	27	Av
4.8 Adequate quantities and types of special hand-tools are available at the base maintenance shop.	E	83	17				-1
	F	29	14	14	14	29	-1
	Av.	40	16	6	4	34	Av
4.9 Standard/common handtools have to be re-leased fromhandtool storerooms.	E					100	-1
	F	12				88	-1
	Av.	11	2		2	85	Av
4.10 Special handtools have to be released from handtool storerooms.	E					100	-1
	F	12			13	75	-1
	Av.	8	5	2	3	82	Av
4.11 A complete set of tools is issued to each maintenance technician.	E	22				88	-1
	F					100	-1
	Av.	5			3	92	Av

ponse (Normalized)												
	by Equipment (% of Time)											
10-0	Eqpt.	100-90	90-70	70-30	30-10	10-0	Eqpt.	100-90	90-70	70-30	30-10	10-0
78	-124		13	13	21	53						
63	-127(V)	7			8	85						
60	Av.	5	4	12	19	60						
11	-124	65	14	14	7							
	-127(V)	85	8	7								
4	Av.	62	19	11	4	4						
78	-124		7	14	22	57						
57	-127(V)	8	0	8	15	69						
57	Av.	7	4	11	21	57						
	-124	80	20									
	-127(V)	69	23	8								
	Av.	75	22	2	1							
11	-124	53	20	13	7	7	-27A	46	14	7	15	18
13	-127(V)	38		15	8	39	-47	66	17		17	
16	Av.	50	13	9	12	16						
	-124	54	15		8	23						
29	-127(V)	55	9	18		18						
27	Av.	48	16	6	3	27						
	-124	58	9	8		25	-27A	22	28	6		44
29	-127(V)	36	9	10	9	36	-47	50	16		17	17
34	Av.	40	16	6	4	34						
100	-124					100						
88	-127(V)	17				83						
85	Av.	11	2		2	85						
100	-124				7	93						
75	-127(V)	8				92						
82	Av.	8	5	2	3	82						
88	-124	7				93						
100	-127(V)					100						
92	Av.	5			3	92						

TABLE 34. (Continued)

Eqpt.	100-90	90-70	70-30	30-10	10-0	Technician's Comments
-27A	46	14	7	15	18	
-47	66	17		17		
-27A	22	28	6		44	
-47	50	16		17	17	

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3

	Quantitative Respo					
	by Base (% of Time)					
	Base	100-90	90-70	70-30	30-10	10-0
4.12 A complete set of tools is issued to each site.	E	75				25
	F	72		14		14
	Av.	75	6	4	1	14
4.13 A complete set of tools is issued to the base maintenance shop.	E	72			14	14
	F	57	14			29
	Av.	63	6	4	4	23
4.14 Site handtools are described and recommended in system related handbooks.	E	45	22	11		22
	F	29	14	14	14	29
	Av.	49	24	9	5	13
5.1 Adequate assembly sparing is maintained in inventory.	E	33			22	45
	F	38	12	12		38
	Av.	26	19	7	13	35
5.2 Adequate subassembly (board) sparing is maintained in inventory.	E	63	12	13		12
	F	29	29	14	14	14
	Av.	47	27	8	3	15
5.3 Critical assembly sparing (high failure rate units) is adequate.	E	33		34		33
	F	38	25	12		25
	Av.	39	16	12	6	27
5.4 Critical assembly (board) sparing is adequate.	E	56		11	11	22
	F	57	29		14	
	Av.	50	24	4	8	14
5.5 Replenishing spares inventories is directly related to assembly/subassembly (board)/component demand by site or maintenance shop personnel.	E	33	11		11	45
	F	75	25			
	Av.	52	18	8	6	16
5.6 Replenishing spares inventories is directly related to spares provisioning estimates.	E	45	11	22	11	11
	F	29	29	14	14	14
	Av.	34	20	21	12	13

TABL

tive Response (Normalized)													
		by Equipment (% of Time)											
10	10-0	Eqpt.	100-90	90-70	70-30	30-10	10-0	Eqpt.	100-90	90-70	70-30	30-10	10-0
	25	-124	57	14			29						
	14	-127(V)	91		9								
	14	Av.	75	6	4	1	14						
	14	-124	57	14	7		22						
	29	-127(V)	64	9			27						
	23	Av.	63	6	4	4	23						
	22	-124	64	7	8	7	14						
	29	-127(V)	42	25	25	8							
	13	Av.	49	24	9	5	13						
	45	-124	33			7	60	-27A	21	36	11	18	14
	38	-127(V)	7	8	8	8	69	-47	83	17			
	35	Av.	26	19	7	13	35						
	12	-124	86	14				-27A	25	50	14	7	4
	14	-127(V)	17		8		75	-47	83	17			
	15	Av.	47	27	8	3	15						
	33	-124	33	20	7	7	33	-27A	41	18	18	4	19
	25	-127(V)	22	8	8	8	54	-47	58	17	8	9	8
	27	Av.	39	16	12	6	27						
	22	-124	72	21	7			-27A	36	32	7	18	7
		-127(V)	31	7			62	-47	75	25			
	14	Av.	50	24	4	8	14						
	45	-124	73	7			20	-27A	43	25	14	11	7
		-127(V)	42	8	9	8	33	-47	58	25			17
	16	Av.	52	18	8	6	16						
	11	-124	62	15	8	15		-27A	24	12	32	20	12
	14	-127(V)	23	15	31		31	-47	36	46	9		9
	13	Av.	34	20	21	12	13						

TABLE 34. (Continued)

10-0	Eqpt.	100-90	90-70	70-30	30-10	10-0	Technician's Comments
29 14							
22 27 23							
14 13							
60 69 35	-27A -47	21 83	36 17	11	18	14	
75 15	-27A -47	25 83	50 17	14	7	4	
33 54 27	-27A -47	41 58	18 17	18 8	4 9	19 8	
62 14	-27A -47	36 75	32 25	7	18	7	
20 33 16	-27A -47	43 58	25 25	14	11	7 17	
31 13	-27A -47	24 36	12 46	32 9	20	12 9	

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3

	Quantitative Re					
	by Base (% of Time)					
	Base	100-90	90-70	70-30	30-10	10-0
5.7 Replensihing spares inventories generally does impose some supply delay down time for completing assembly repairs.	E	11	11	11	22	45
	F		12	38		50
	Av.	3	6	23	22	46
5.8 Administrative delay down time (delay time other than supply delay) generally does impose restraints to replenishing spares inventories.	E		11		11	78
	F			12	13	75
	Av.	2	3	10	12	73
5.9 Discrete component sparing (common stock for resistors, capacitors, etc) is adequate.	E	38	38	12	12	
	F	29	29	29		13
	Av.	34	32	14	7	13
6.1 Adequate copies of maintenance manuals are available at the site for system maintenance.	E	100				
	F	63	12	25		
	Av.	75	20	4		1
6.2 Adequate copies of maintenance manuals are available at the base maintenance shop for assembly maintenance.	E	67			16	17
	F	40	40			20
	Av.	58	18		2	22
6.3 Maintenance manual instructions provide adequate detail in order to simply and easily perform routine maintenance.	E	89	11			
	F	25	37	38		
	Av.	50	32	14	4	
6.4 Maintenance manual format is consistent with clear and concise instructional procedure.	E	45	33	22		
	F	25	25	50		
	Av.	33	42	21	4	
6.5 Maintenance manuals are generally used for assembly fault isolation at the site.	E	56	11		30	
	F	25	50		25	
	Av.	52	30	6	9	3
6.6 Maintenance manuals are generally used for subassembly (board) fault isolation at the site.	E	67	11		22	
	F	43	14	29	14	
	Av.	60	22	10	6	2

titative Response (Normalized)

		by Equipment (% of Time)											
0-10	10-0	Eqpt.	100-90	90-70	70-30	30-10	10-0	Eqpt.	100-90	90-70	70-30	30-10	10-0
2	45	-124	7		13	20	60	-27		11	26	33	30
	50	-127(V)	8		15	15	62	-47		8	33	9	50
2	46	Av.	3	6	23	22	46						
1	78	-124		6	7		87	-27A		4	12	19	65
3	75	-127(V)			8		92	-47	8		17	25	50
2	73	Av.	2	3	10	12	73						
2		-124	23	15	8		54	-27A	30	30	20	16	4
	13	-127(V)	54	38		8		-47	25	42	25		8
7	13	Av.	34	32	14	7	13						
		-124	87	7	6								
		-127(V)	85	15									
	1	Av.	75	20	4		1						
6	17	-124	70	15			15						
	20	-127(V)	50	9		8	33	-47	50	33			17
2	22	Av.	58	18		2	22						
		-124	47	40	13								
		-127(V)	69	23	8								
4		Av.	50	32	14	4							
		-124	20	60	13	7							
		-127(V)	54	31	15								
4		Av.	33	42	21	4							
0		-124	53	27	7	13							
5		-127(V)	62	15	15	8							
9	3	Av.	52	30	6	9	3						
2		-124	71	14	8		7						
4		-127(V)	62	23	8	7							
6	2	Av.	60	22	10	6	2						

TABLE 34. (Continued)

Eqpt.	100-90	90-70	70-30	30-10	10-0	Technician's Comments
-27 -47		11 8	26 33	33 9	30 50	
-27A -47	 8	4 	12 17	19 25	65 50	
-27A -47	30 25	30 42	20 25	16 	4 8	
-47	50	33			17	

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	Quantitative Resp					
	by Base (% of Time)					
	Base	100-90	90-70	70-30	30-10	10-0
6.7 Maintenance manuals are generally of the latest issue.	E F Av.	89 75 75	11 13 21	 2	 12 2	
6.8 Maintenance manuals are extensively stressed during technician training for system maintenance.	E F Av.	56 75 66	22 13 25	22 6	 12 2	 1
6.9 Approximately percent of every corrective maintenance activity on the system is preoccupied with maintenance manual study. (a) 100-80, (b) 80-60, (c) 60-40, (d) 40-20, (e) 20-0.	E F Av.	 25 25	12 12 16	13 17	50 50 28	25 13 14
6.10 Approximately percent of every corrective maintenance activity on assemblies is preoccupied with maintenance manual study. (a) 100-80, (b) 80-60, (c) 60-40, (d) 40-20, (e) 20-0.	E F Av.	 25 30	25 12	 12 17	50 50 30	25 13 11
6.11 Approximately percent of every corrective maintenance activity on subassembly (board) is preoccupied with maintenance manual study. (a) 100-80, (b) 80-60, (c) 60-40, (d) 40-20, (e) 20-0.	E F Av.	14 25 30	14 13 16	14 16	29 50 20	29 12 18
7.1 System operators are required to perform fault isolation or maintenance.	E F Av.	 38 12	 3		11 3	89 62 82
7.2 System operators are formally trained to perform fault isolation or maintenance.	E F Av.	 38 16			11 3	89 62 81
7.3 System Operators are trained maintenance technicians.	E F Av.	 25 11	 12 2		 2	100 63 85

tive Response (Normalized)													
		by Equipment (% of Time)											
0	10-0	Eqpt.	100-90	90-70	70-30	30-10	10-0	Eqpt.	100-90	90-70	70-30	30-10	10-0
		-124	93	7									
		-127(V)	92		8								
		Av.	75	21	2	2							
		-124	60	27	13								
		-127(V)	69	15	8	8							
	1	Av.	66	25	6	2	1						
	25	-124	18	9	9	55	9						
	13	-127(V)	25	12	19	32	12						
	14	Av.	25	16	17	28	14						
	25	-124	20	10	20	50							
	13	-127(V)	31	6	19	25	19						
	11	Av.	30	12	17	30	11						
	29	-124	10	20	10	20	40						
	12	-127(V)	25	19	12	25	19						
	18	Av.	30	16	16	20	18						
	89	-124	7				93						
	62	-127(V)	15			15	70						
	82	Av.	12	3		3	82						
	89	-124	14				86						
	62	-127(V)	25			8	67						
	81	Av.	16			3	81						
	100	-124	14				86						
	63	-127(V)	8	7			85						
	85	Av.	11	2		2	85						

TABLE 34. (Continued)

Eqpt.	100-90	90-70	70-30	30-10	10-0	Technician's Comments

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	Quantitative Re					
	by Base (% of Time)					
	Base	100-90	90-70	70-30	30-10	10-0
7.4 System operators are experienced maintenance technicians.	E					100
	F		14	14		72
	Av.	4	6	3	2	85
7.5 Maintenance technicians are required to complete formal training on the system in order to qualify for systemmaintenance.	E	44				56
	F	75	25			
	Av.	59	12	2	4	23
7.6 Maintenance technicians are required to complete weeks of formal system training. (a) none, (b) six or less, (c) 12 or less, (d) more than 12.	E	63	12		25	
	F	17	16	17	50	
	Av.	27	32	7	34	
7.7 Maintenance technicians are required to complete weeks of on-site training and/or instruction prior to qualifying for system maintenance. (a) none, (b) six or less, (c) 12 or less, (d) more than 12.	E		67	11	22	
	F		50	50		
	Av.	5	31	29	35	
7.8 Maintenance technicians are required to complete weeks of contractor-conducted training and/or instruction prior to qualifying for system maintenance. (a) none, (b) six or less, (c) 12 or less, (d) more than 12.	E	78	22			
	F	83			17	
	Av.	75	16	7	2	
7.9 System maintenance technicians are required to perform assembly maintenance.	E	78	11	11		
	F	88	12			
	Av.	75	16	1	5	3
7.10 System maintenance technicians receive additional training to qualify for assembly maintenance.	E	22		22		56
	F	14	15		14	57
	Av.	24	10	13	13	40
7.11 System maintenance technicians are instructed using validated maintenance handbooks.	E	78	22			
	F	63	25		12	
	Av.	78	15	3	3	1

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		tative Response (Normalized)											
		by Equipment (% of Time)											
10	10-0	Eqpt.	100-90	90-70	70-30	30-10	10-0	Eqpt.	100-90	90-70	70-30	30-10	10-0
	100	-124		14			86						
	72	-127(V)			9		91						
	85	Av.	4	6	3	2	85						
	56	-124	64	29		7							
		-127(V)	62	7			31						
	23	Av.	59	12	2	4	23						
		-124		85	8	7		-27A	53	8	12	27	
		-127(V)	25	58		17		-47				100	
		Av.	27	32	7	34							
		-124		27	18	55		-27A	9	25	49	17	
		-127(V)	9	73	9	9		-47			11	89	
		Av.	5	31	29	35							
		-124	85	15									
		-127(V)	67	25		8							
		Av.	75	16	7	2							
		-124	79	21									
		-127(V)	77	15			8						
	3	Av.	75	16	1	5	3						
	56	-124	46	8	15		31	-27A	25	7	8	21	9
	57	-127(V)		9	9	18	64	-47	18	19	27		36
	40	Av.	24	10	13	13	40						
		-124	80	13			7						
		-127(V)	77	15		8							
	1	Av.	78	15	3	3	1						

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TABLE 34. (Continued)

-0	Eqpt.	100-90	90-70	70-30	30-10	10-0	Technician's Comments
6 1 5							
1 3							
	-27A -47	53	8	12	27 100		
	-27A -47	9	25	49 11	17 89		
8 3							
1 4 0	-27A -47	25 18	7 19	8 27	21	9 36	
7 1							

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	Quantitative Response						
	by Base (% of Time)						
	Base	100-90	90-70	70-30	30-10	10-0	Eqpt.
7.12 System operators are required to achieve at least a minimum skill level rating of (a) 3, (b) 5, (c) 7.	E F Av.	 18	100 100 80	 2			-124 -127(Av.
7.13 System maintenance technicians are required to achieve at least a minimum skill level rating of (a) 3, (b) 5, (c) 7.	E F Av.	 8	100 88 86	 12 6			-124 -127(Av.
7.14 Assembly maintenance technicians are required to achieve at least a maximum skill level rating of (a) 3, (b) 5, (c) 7.	E F Av.	 7	100 100 90	 3			-124 -127(Av.
7.15 System maintenance technicians are trained using system-related cost equipment.	E F Av.	56 75 59	 21	33 10	11 12 3	 13 7	-124 -127(Av.
7.16 System operators are military personnel.	E F Av.	100 100 97	 1		 1	 1	-124 -127(Av.
7.17 System operators are civilian personnel.	E F Av.			 2	 3	100 100 95	-124 -127(Av.
7.18 System maintenance technicians are military personnel.	E F Av.	100 100 91	 9				-124 -127(Av.
7.19 System maintenance technicians are civilian personnel.	E F Av.				 7	100 100 93	-124 -127(Av.
7.20 Assembly maintenance technicians are military personnel.	E F Av.	100 100 85	 9	 6			-124 -127(Av.
7.21 Assembly maintenance technicians are civilian personnel.	E F Av.			 3	 9	100 100 88	-124 -127(Av.

TABLE 34. (

Response (Normalized)													Te
	by Equipment (% of Time)												
)-0	Eqpt.	100-90	90-70	70-30	30-10	10-0	Eqpt.	100-9(	90-70	70-30	30-10	10-0	
	-124	11	89										
	-127(V)	22	78										
	Av.	18	80	2									
	-124	6	87	7									
	-127(V)	17	75	8									
	Av.	8	86	6									
	-124	7	93										
	-127(V)	9	82	9									
	Av.	7	90	3									
	-124	60	13	13	7	7							
13	-127(V)	54	8	23	7	8							
7	Av.	59	21	10	3	7							
	-124	93				7							
	-127(V)	100											
1	Av.	97	1		1	1							
)0	-124					100							
)0	-127(V)					100							
)5	Av.			2	3	95							
	-124	93	7										
	-127(V)	92	8										
	Av.	91	9										
)0	-124				7	93							
)0	-127(V)					100							
)3	Av.				7	93							
	-124	93	7										
	-127(V)	91	9										
	Av.	85	9	6									
)0	-124				7	93							
)0	-127(V)					100							
8	Av.			3	9	88							

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TABLE 34. (Continued)

-0	Eqpt.	100-9	90-70	70-30	30-10	10-0	Technician's Comments
7 8 7							
7 1							
0 0 5							
3 0 3							
3 0 3							

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	Quantitative Res					
	by Base (% of Time)					
	Base	100-90	90-70	70-30	30-10	10-0
7.22 System operators are career-oriented personnel.	E	25	25	38		12
	F		29	71		
	Av.	10	17	52	13	8
7.23 System maintenance technicians are career-oriented personnel.	E	22	22	45	11	
	F		14	86		
	Av.	15	16	55	14	
7.24 Assembly maintenance technicians are career-oriented personnel.	E	22	22	45	11	
	F		14	86		
	Av.	12	15	60	11	2
7.25 System test capability provides complete built-in test for assembly fault isolation.	E		34	22	22	22
	F		29	14	29	28
	Av.	8	24	22	22	24
8.1 System test capability provides complete built-in test for assembly fault isolation.	E			11	44	45
	F		29	14	14	43
	Av.		18	28	20	34
8.2 Assembly test capability provides complete built-in test for lower level fault isolation.	E	67	33			
	F	50	50			
	Av.	60	33	6	1	
8.3 System test equipment is available at the site when needed.	E	57	14	15		14
	F	33	34			33
	Av.	52	17	5		26
8.4 System test equipment is available at the base maintenance shop when needed.	E	67	33			
	F	50	50			
	Av.	55	34	5	3	3
8.5 System test equipment is available at the base maintenance shop when needed.	E	67	33			
	F	50	50			
	Av.	55	34	5	3	3

10	10-0	Eqpt.	100-90	90-70	70-30	30-10	10-0	Eqpt.	100-90	90-70	70-30	30-10	10-0
	12	-124	8	15	46	8	23	-27A	12	16	48	20	4
		-127(V)	8	17	67		8	-47	10	20	50	20	
	8	Av.	10	17	52	13	8						
		-124	14	8	64	14							
		-127(V)	8	15	77								
		Av.	15	16	55	14							
		-124	14	8	64	14							
		-127(V)	8	17	67	8							
	2	Av.	12	15	60	11	2						
	22	-124		29	29	21	21						
	28	-127(V)			7	8	85						
	24	Av.	8	24	22	22	24						
	45	-124		23	23	31	23						
	43	-127(V)			9		91						
	34	Av.		18	28	20	34						
		-124	60	33		7							
		-127(V)	69	23	8								
		Av.	60	33	6	1							
	14	-124	42	17			41	-27A	54	15			31
	33	-127(V)	73	18			9	-47	33	17	33		17
	26	Av.	52	17	5		26						
		-124	53	33			14	-27A	46	39	8	7	
		-127(V)	83	17				-47	50	42	8		
	3	Av.	55	34	5	3	3						
		-124	53	33			14						
		-127(V)	83	17									
	3	Av.	55	34	5	3	3						

TABLE 34. (Continued)

-0	Eqpt.	100-90	90-70	70-30	30-10	10-0	Technician's Comments
3	-27A	12	16	48	20	4	
8	-47	10	20	50	20		
8							
2							
1							
5							
4							
3							
1							
4							
1	-27A	54	15			31	
9	-47	33	17	33		17	
6							
4	-27A	46	39	8	7		
	-47	50	42	8			
3							
4							
3							

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	Quantitative Res					
	by Base (% of Time)					
	Base	100-90	90-70	70-30	30-10	10-0
8.6 Assembly test equipment is available at the base maintenance shop when needed.	E F Av.	67 33 39	17 17 15	16 12		 50 34
8.7 Subassembly (board) test equipment is available at the site when needed.	E F Av.	75 50 46	13 25 23	12 8	 12 6	 13 17
8.8 Subassembly (board) test equipment is available at the base maintenance shop when needed.	E F Av.	72 14 33	14 14	 15 7	 14 6	14 57 40
8.9 Contractor-recommended system test equipment is available in the logistic inventory.	E F Av.	72 40 53	14 40 22	 20 3	 5	14 17
8.10 Test equipment availability is adequate to accommodate every corrective maintenance activity.	E F Av.	67 38 46	22 50 43	11 4	 12 6	 1
8.11 Test equipment availability is adequate to accommodate every preventive maintenance activity.	E F Av.	56 62 60	44 13 26	 25 8	 4	 2
8.12 Test equipment most readily available when needed for corrective maintenance can be identified in the following sequential order. (a) waveform generators, (b) volt/amp meters, (c) oscilloscopes, (d) RF cables, (e) power meters.	E F Av.	 10	 16	 17	 14	 10
8.13 Test equipment calibration scheduling is a factor with regard to routine equipment availability.	E F Av.	22 38 20	11 25 20	22 12 20	11 20	34 25 20

TAB

itative Response (Normalized)													
		by Equipment (% of Time)											
-10	10-0	Eqpt.	100-90	90-70	70-30	30-10	10-0	Eqpt.	100-90	90-70	70-30	30-10	10-0
		-124	42	8			50	-27A	17	8	25		50
	50	-127(V)	73	18			9	-47	17	33	33		17
	34	Av.	39	15	12		34						
		-124	22	14		21	43	-27A	37	33	15	4	11
	13	-127(V)	62	15	8		15	-47	83	17			
	17	Av.	46	23	8	6	17						
	14	-124	17	8		17	58	-27A	13	20	14	6	47
	57	-127(V)	60	20			20	-47	67		16		17
	40	Av.	33	14	7	6	40						
	14	-124	50	7	14		29						
		-127(V)	58			8	33						
	17	Av.	53	22	3	5	17						
		-124	53	47									
		-127(V)	54	38		8							
	1	Av.	46	43	4	6	1						
		-124	87	7	6								
		-124(V)	77	15	8								
	2	Av.	60	26	8	4	2						
		-124											
		-127(V)											
	10	Av.											
	34	-124	29	21	7	21	22						
	25	-127(V)	23	15	39		23						
	20	Av.	20	20	20	20	20						

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TABLE 34. (Continued)

10-0	Eqpt.	100-90	90-70	70-30	30-10	10-0	Technician's Comments
50 9 34	-27A -47	17 17	8 33	25 33		50 17	
43 15 17	-27A -47	37 83	33 17	15	4	11	
58 20 40	-27A -47	13 67	20	14 16	6	47 17	
29 33 17							
1							
2							
22 23 20							

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MISSION

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RADC plans and conducts research, exploratory and advanced development programs in command, control, and communications (C^3) activities, and in the C^3 areas of information sciences and intelligence. The principal technical mission areas are communications, electromagnetic guidance and control, surveillance of ground and aerospace objects, intelligence data collection and handling, information system technology, ionospheric propagation, solid state sciences, microwave physics and electronic reliability, maintainability and compatibility.

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